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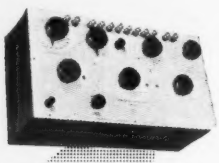

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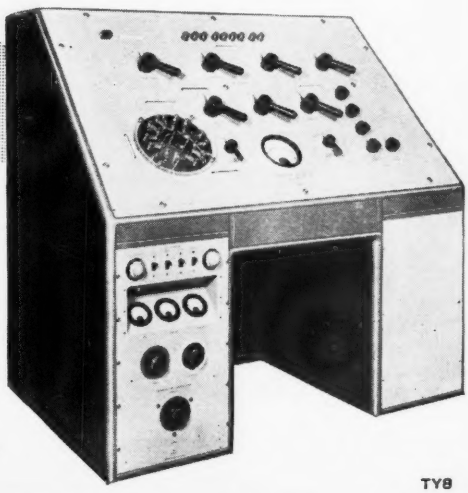

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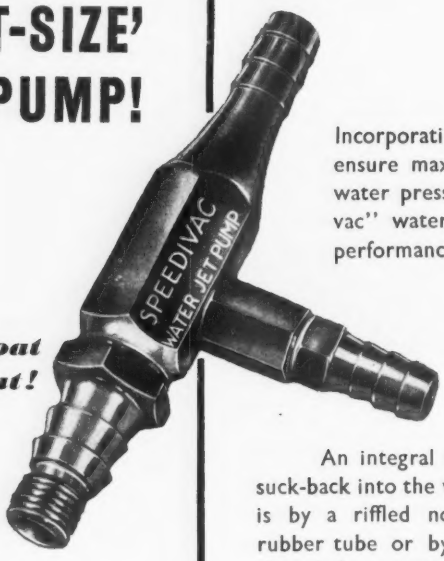

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MASS MEDIA OF COMMUNICATION AND SCIENTIFIC DEVELOPMENTS

IN his Rede Lecture, "The Two Cultures and the Scientific Revolution", Sir Charles Snow pointed out that a knowledge of science among the public was one of four essential conditions if Britain was to meet the challenge of the scientific revolution and, by seizing the opportunities that revolution offers, avoid a steep decline in our standard of living. This knowledge was necessary not only for politicians and administrators but also for the whole community, who should know enough science to have a sense of what the scientists are doing. This involves, as Sir John Cockcroft has pointed out, a definite effort to remove the language barrier between the public and the scientist, which makes it difficult even for those who are aware that science affects the life of the community to understand how science works and its implications for the community. Sir John thought that in the everyday business of administration scientists had mostly succeeded in their effort to explain their work in plain language to politicians, Civil servants, diplomats and business men, but this is only a part of the problem of communication It is no less important that science should be better understood by the man in the street.

This is in part a problem of formal education. Increasingly it is also a matter of using effectively the ways of communication at our disposal, and this means especially the mass media of the popular Press, sound broadcasting and television. Only if wide and effective use is made of these media can we hope to keep the public sufficiently informed about scientific and technical advances for such discoveries to be put to either personal or public use, and, no less important, for the possibilities of abuse to be eliminated or minimized. Nor is this entirely a matter of appropriate techniques or of the standard of public education. We need to know much more about the way in which scientific information reaches the public and how much of it really penetrates to the public consciousness; and about the general attitudes, or even prejudices, regarding science and scientists which certainly exist in the minds of the public.

These questions have been examined in a series of surveys sponsored by the National Association of Science Writers, Inc., of the United States (Five Longview Road, Port Washington, N.Y.), and although the reports relate strictly to the United States, their findings and conclusions are unlikely to be entirely invalid in Britain. The surveys point to obstacles which exist no less in Britain than in the United States and they suggest ways in which communication could be improved here also, and dangers which threaten in differing degree rather than in differing kind. Moreover, while a similar survey in Britain might not establish the existence of a large reservoir of interest in science reporting, with readers, listeners and viewers prepared to surrender other news and entertainment features to become better informed about science, it might well disclose the existence of sufficient interest to halt the present lowering of standards. Indeed, failure to do so would provide a damning indictment of our educational system and point to an early decline to a third- or fourth-rate power.

The first of these reports, "Science, the News and the Public", describes a sample survey of 1,919 American adults, selected to represent a cross-section of the public, conducted by the Survey Research Center, University of Michigan, and also sponsored by New York University, to ascertain who get what science news, where they get it and what they think about it. The second report, "The Public Impact of Science in the Mass Media", describes a nation-wide survey conducted by the same Center and supported by a grant from the Rockefeller Foundation with the specific objectives of ascertaining the size and composition of the major mass media audiences, how science news fits into the news-reading patterns of the newspaper audience, and the conceptions and attitudes of the public relating to science and scientists; determining the size and characteristics of the science audiences of the media; describing the content of science news which has been read, heard and seen; obtaining the science audiences' evaluation of the way in which science news is presented; analysing the social and psychological factors that affect the consumption of science news; examining the effect of differential wording of science news items on the level of reader interest; and estimating the distribution of science information among the public. This survey was based on a pilot study in 1955 of a non-random sample of 200 respondants. The third report, "Satellites, Science and the Public", describing a national survey of the impact on the public of early satellite launchings, is a follow-up of the main survey. It was conducted a year later, and it is focused on the changes revealed in the answers to questions regarding the Earth satellites put before and after the launching of the first satellite.

The first report provides evidence that in the United States the mass media could reasonably increase the present cover of scientific developments, and it is argued that, with increasing numbers of students in high school and college, many of whom will be studying science, there should be a great expansion in the demand for science coverage in the channels of popular communication. Much of the information in the mass media does reach the public mind, and on the evidence of this survey an impressive amount of this science information is retained. The report once again directs attention to the room for improvement in the popular reporting of scientific developments, but beyond the observation that reporters and script-writers, given more training and time in assignments, would be able to provide more details, greater background, better interpretation

and, possibly, higher accuracy, the report does not pursue this important theme. It is conceded that such changes might help to correct present distortions in the public image of science and scientists and promote the idea that they are part of, not divorced from, contemporary living; but the conclusion stands that science is not constantly covered in the United States and that Americans lack information on which to decide intelligently public matters involving science, scientists, and possibly their own existence.

These conclusions are substantially supported by the larger study. Available evidence suggests that even allowing for a possible boom in science news stimulated by the launching of Earth satellites, the mass media are transmitting only a microscopic part of the supply of scientific information potentially available. Since 76 per cent of the sample could recall one or more science items they had read or seen recently, 64 per cent recalling at least one item from the newspapers, 34 per cent from magazines, 13 per cent from radio and 41 per cent from television, it would seem that the demand has been greatly under-estimated.

In the United States the mass media together cover all but 1 per cent of the private dwelling units of the country and at least a quarter or a third of every social category uses three media. Papers appear to be the primary source of general views, and while the greatest change in the media used during the past decade has been the rapid spread of television, the written media have held their audiences well. The combined science audience appears to include three out of four adults, and newspapers are the most important source of science news and radio the least. Papers, magazines and television are mutually supplementary as sources of science news, but radio is weak both as a primary and secondary source. Newspapers appear to take a key role in transmitting both science and medical news to this large science audience and there is generally a positive reaction towards science as it is presented in the mass media.

The report then analyses in a separate chapter more particularly the newspaper audience, the magazine, radio and television audiences being considered in a following chapter. While it is clear that science news is not read solely by the intellectual *élite*, the survey suggests that reading of non-medical science news is associated with a cosmopolitan and rather intellectual orientation towards news content, while medical news tends to be read by those with a more personalized local point of view. Education and income-levels are reflected in science reading of both types and also in the extent to which actual news items are recalled. Even in the social categories least prone to read science news, a sizeable minority is reached by the presentation of science in the Press.

As regards magazines, the survey points to a relatively *élite* audience compared with the other media, and in general magazine readers of science in the United States appear to be highly satisfied with the way their medium presents science. The newspaper is the most important supplementary medium for these readers. The radio audience of science, however, appears to be scanty, and although the audience is spread very evenly through the population, the completeness and accuracy of science news on the radio receive adverse comment. Again, the newspapers provide much supplementary information for this group. Television has not yet challenged the lead of the newspaper, and its potentialities for the transmission of science news are regarded as largely unexplored, but there is evidence in this report that a good deal of care will be required in developing this field if science information is to be presented without exaggeration and distortion.

Subsequent chapters consider briefly the forms and channels in which science news is presented in relation to effective presentation, but the data are too scanty for more than tentative evaluations of presentation to be made. The evidence indicates that additional interest is more readily stimulated the more a person is already interested in science, but nevertheless more vivid or stimulating presentation does affect those who are not already interested or trained in science. Education in science is, however, important as providing both the necessary background and a sensitivity to scientific topics. The evidence presented in this report fully supports the argument that sufficient general science should be a part of the education of every citizen to enable him or her to understand how science works, what it is about and something of its meaning in the world to-day.

This factor can obviously determine attention or indifference to science news and the report seeks to analyse these motives. Most of those interviewed were willing to have other news cut to get more science news in the papers, but the reasons for interest in science most cited were fairly broad, and orientation to science seemed to serve the broader functions of making sense of the world and helping to manage one's relations to it. This, of course, indicates the importance of presenting science in its context and not presenting pieces of information or facts in isolation.

Finally, the survey examines the current attitudes to science and the world which go so far to determine the public understanding or misunderstanding of science as it is presented to them to-day. When asked to strike a balance of the effects of science on the world the public overwhelmingly stresses the good effects. These are seen primarily as improvements in health, standard of living and technological advance, and the direct ill-effects on the world are seen almost entirely in terms of the destructive potential of nuclear energy. Concern about the detrimental effects of science on the social order and the deviating traits of scientists was an underlying theme, and the report, besides noting that people who are highly concerned about such issues are likely to advocate limiting scientific research, points out that in times of crisis these ambivalent attitudes could lead to a more negative picture of science.

The report on the survey of the public impact of early satellite launchings shows that almost half the adult population of the United States became aware of the satellites in a single year: 90 per cent had heard of the satellites by mid-1958 compared with less than 50 per cent a year earlier. Less than one-third of those aware of the satellites thought of them as having primarily an immediate scientific purpose; about one-fourth knew of no purpose. Both awareness of the satellites and of their scientific purpose was related to the education, income and number of media used by the person, and the evaluation of science and scientists was overwhelmingly favourable in both these comparative surveys. Within the newspaper audience there was a moderate increase in readership of science.

The comparative survey provides further evidence that awareness of a scientific event or finding can be stimulated in all strata of the public if enough news concerning the event can be made available to the audience, and that it is probable the public reaction to a scientific event is largely determined by a desire to understand and master the world as seen by the individual. Increase of interest in a particular area of science due to a major break-through in knowledge or achievement is unlikely to stimulate interest in other scientific areas unless the public sees definite links between the areas. The pattern of public reactions to science and scientists is a complex and pervasive phenomenon, and the generally favourable attitude to science and scientists is regarded as more stable than the public's notions of the boundaries of scientific endeavour. Science and scientific events, however, do not operate in a vacuum and some aspects of the public's evaluation of science are liable to change. It seems likely that the public is less concerned with what science is than with what it accomplishes.

These generalizations are scarcely new to the scientific writer and are indeed part of the everyday technique of communication. On the actual technique of communication, however, these reports throw little light. They are of interest to British readers rather for the attention they direct to certain dangers as well as to trends and objectives in the use of mass media and perhaps especially to the fundamental importance of education. They underline, indeed, the importance of the investigation of the educational potentialities of the mass media on which Mr. J. Trenaman has been engaged for the past three years with the support of the Nuffield Foundation, and provide substantial evidence that effective use cannot be made of the mass media, and perhaps especially of television, if our educational system is defective. Shortcomings there will not be remedied by the mass media.

Indeed, if one generalization is to be drawn from these reports, it is that the mass media are unlikely to prove a reliable method of increasing the public understanding of science unless the mass audience has itself already been prepared by its general formal education to understand what science is about and the place it takes in the world to-day. Without this the dangers of abuse, particularly of broadcasting and television, to which renewed attention was directed in the debate in the House of Lords on June 3, and by Mr. H. Carleton Greene, the recently appointed director-general of the British Broadcasting Corporation, in an address* to German business men on April 18, and by Dr. M. Conran in his article on the Third Programme, will remain formidable. There is little in the American survey to suggest that Field-Marshal Smuts was unduly pessimistic in regarding the disappearance of the sturdy, independent-minded, freedom-loving individual and his replacement by a servile, standardized, mass-mentality as the greatest human menace of our time. Indeed, it is almost inherently impossible for the mass media themselves to check this process. Lord James of Rusholme in the Lords debate remarked that one cannot use all the techniques of mass persuasion, appeal consistently to the facile, the uncritical and the escapist, and still talk of freedom.

The debate in the House of Lords did not resolve this issue. It focused attention rather upon the question of public responsibility, and strong support was forthcoming for the view that television, as well as sound broadcasting, should be made entirely responsive to the public interest and, whether in the public or in the private sector, subject to impartial review. Lord James was forthright on the importance of this sense of public responsibility and of television and broadcasting being independent of any political or commercial pressure, so that new facilities could be freely used and in new ways if we are to foster an educated democracy, as critical, as knowledgeable and as free as we can make it.

There was little support in the debate for further extension of television programmes but some for the improvement of programmes and for technical research. Lord Hailsham seemed to stand alone in his reply for the Government in professing satisfaction with the present position and no concern about the possibility of abuse or debasement of standards. This was Mr. Carleton Greene's main concern, however, and, arguing that radio and television are too powerful in the potential long-term effects for their control to be entrusted to either politicians or business men, he points out that once the fairness and impartiality of a broadcasting system become suspect its authority as a source of information is destroyed. He quotes American experience to show how liable this is to happen in commercial television, and he suggests further that available evidence points to the conclusion that commercially controlled broadcasting tends, in the long run, to undermine the intelligence, at any rate, of its constant listeners and viewers, and makes it more difficult for them to appreciate programmes which demand some thought and application. It makes them passive rather than active.

This can be particularly serious for children, and the possibility is the more disturbing in that the American survey confirms so strongly the determining

* Two Threats to Broadcasting: Political and Commercial Control. By H. Carleton Greene. Pp. 8. (London: British Broadcasting Corporation, 1959.)

influence of early education brought out in Mr. Trenaman's study. The most powerful influence in effective communication is the full-time education received in childhood and early youth; and alike in resisting the detrimental or anti-social influences of broadcasting or in realizing the potentialities of these new media for adult education this is the decisive factor. It far outweighs the importance of technical improvements in the use of television or sound broadcasting for educational purposes, and though Mr. Greene's address at first sight seems to bear only indirectly on the American inquiry, it should be clear that any attempt to improve the use of the mass media to disseminate scientific information and advance the public understanding of science could well fail if it did not take account of this factor, and if it ignored the consequences of political and sectional pressure debasing the media.

Mr. Greene does not ignore the beneficial results which a public service broadcasting system can bring and he points out that B.B.C. television has, contrary to expectation, had in England a favourable effect on reading habits rather than otherwise. The use of radio and television in schools, however, is quite a separate issue. What needs to be emphasized first is the crucial importance of an adequate system of education in the schools if the level of public understanding of science is to be raised. That comes first, and no improvements in the techniques of presentation and of using the mass media can compensate for shortcomings there. Further, with the realization of the opportunities which television and also sound broadcasting should increasingly offer, if wisely used, for communicating scientific information, there should be a keen appreciation of the irreparable damage that can be done both to the reputation and effectiveness of the medium and to public intelligence if these media are rashly and irresponsibly used.

EGYPT AND GREECE IN MEDICAL HISTORY

Ancient Egyptian and Cnidian Medicine

The Relationship of Their Aetiological Concepts of Disease. By Robert O. Steuer and J. B. de C. M. Saunders. Pp. xii+90. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1959.) 22*s*. 6*d*. net.

THE authors of this interesting and constructive, though highly specialized, book introduce the problem which they seek to expound by the statement that "throughout the history of medicine the physician has searched for a theory of disease through which he might organize a diversity of data and thus justify his practice by establishing a scientific system". This is an elaborate way of saying that for centuries doctors have been looking for an easy way of practising by rule-of-thumb. Even in ancient Egypt this search had begun, although many medical historians have regarded the contribution of Egypt to modern medicine as negligible, because it was magico-religious, and entirely devoid of any rational approach. The recent re-examination of the existing medical papyri has placed Egyptian medicine in quite a different category, and has confirmed the view, previously advanced with little supporting evidence, that the Greeks, acknowledged to be the first to base their medical practice upon observation rather than upon theory, drew many of their ideas from the Egyptians. The first to profit from the Egyptian impact was the pre-Hippocratic School of Cnidos (on the mainland opposite the island of Cos). Cnidian medicine, however, was apt to confuse symptoms with diseases, and it was not until Hippocrates of Cos insisted upon the need for observation, and upon the importance of prognosis rather than diagnosis, that the great era of Greek medicine was inaugurated.

The present work deals with the link between Egypt and Cnidos. Both were preoccupied with the idea of putrefaction as a cause of disease, and with the means of preventing it. The prevention of corruption had been carried to a fine art by those who embalmed the human body after death, and this process of mummification was based upon the principle which was followed also by those who sought to heal the living body by getting rid of putrefaction within it. It was alleged that disease was caused by the *materia peccans* in the fæcal content of the bowel. It logically followed that treatment must consist of eliminating the noxious agent or putrefying matter by purgatives or enemata.

The writers of the book under review give many examples of this etiological concept, culled from various papyri, especially the "Papyrus Anonymous Londinensis", besides a number of Greek writings. Although the Cnidian notions appear to have been supplanted by the idea of the humours, favoured by Hippocrates and the Coan School, the two opinions were to some extent united when it was admitted that even the humours might be corrupt or putrefying. This idea paved the way for the doctrine of the ethereal 'miasma' as a cause of disease, an idea which held the field for centuries in various guises until at length the pathogenic nature of bacteria was demonstrated. The relationship between the ideas of Egypt and those of Greece is a significant chapter in the history of medicine, and Dr. Steuer and Prof. Saunders are to be congratulated on their careful and well-documented study of the putrefactive principle in ancient writings. Besides the 55 pages of text, there are an appendix expounding the views of Galen on the matter, and another, suggesting that air-borne disease may have been envisaged even in ancient Egypt. There are twelve pages of informative notes and a bibliography, as well as an adequate index.

Douglas Guthrie

THE MOVING FRONT OF CARBOHYDRATES

Advances in Carbohydrate Chemistry, Vol. 13

Edited by Melville L. Wolfrom in association with R. Stuart Tipson. Pp. xi+387. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 88*s*.

VOL. 13 of "Advances in Carbohydrate Chemistry" presents ten reviews on specialized topics of carbohydrate chemistry. Trends of present-day sugar chemistry are reflected in the titles of some contributions and are interwoven in the text of others. Interest in amino-sugars has grown considerably over the past two decades with the recognition that

biologically active mucopolysaccharides and mucoproteins such as heparin, blood group specific substances, virus hæmagglutinin inhibitors and gonadotropins contained N-substituted 2-amino-2-deoxy sugars. Furthermore, sialic acids, containing as nucleus an amino-sugar, have established themselves as regular components of mucoproteins and some mucolipids of animal origin and as constituents of the membrane of certain bacteria. Interest in the impact of alkali on simple sugars, oligosaccharides and polysaccharides has been revived by the discovery of enzymes catalysing aldose – ketose isomerizations, by the realization that the glycosides of β-hydroxyaldehydes and β-hydroxyketones are sensitive to alkalis and by the recognition that the products of alkali degradation of polysaccharides afford valuable information as to the linkage of the constituent units. Finally, the problem of the conformation of the individual sugars enters into nearly every discussion on the reactivity of the carbohydrate concerned.

The topic of sugar-ring conformational analysis attended to in previous volumes is extended by F. Shafizadeh to the formation and cleavage of the oxygen ring in sugars. Shafizadeh discusses various aspects of the interconversion of the cyclic forms and acyclic forms of a sugar. The inductive effect of the hydroxyl groups on the reactive function and the steric effects are well exemplified. The nitrous acid deamination of amino-sugars provides further proof of the profound effect the nature of the adjacent group and the configuration and conformation of the molecule have on the reaction. A concise summary of the preparation and physical properties of the methyl ethers of D- and L-glucosamine, D-galactosamine, D-allosamine and D-altrosamine is provided by R. W. Jeanloz, who has made many contributions to this field. The availability of these ethers renders it possible to apply the methylation procedure of structural analysis to oligo- and poly-saccharides containing amino-sugars.

In the chapter on sialic acids, F. Zilliken and M. W. Whitehouse give a useful account of the composition, structure, determination and distribution of the various sialic acids (N-acylated neuraminic acids). The presentation would have gained in appeal if the authors had stressed the unique arrangement of the functional groups in neuraminic acid (the common parent compound) and interpreted the remarkable properties of this group of substances on the basis of this arrangement. With regard to the linkage of sialic acid in animal mucoproteins it is safe to say that the acid is invariably found as a terminal unit; it seems improbable that it serves as "a chemical bridge between polypeptides and polysaccharides" (p. 238). There is no evidence that the influenza-virus particle has any other enzymic activity than that of an α-neuraminidase (see p. 260). Perhaps I may be allowed to point out that the molecular structure of neuraminic acid, proposed in 1955, was conceived not so much on speculation as on the hard facts that N-acetylneuraminic acid was convertible under mildest alkaline conditions to pyrrole-2-carboxylic acid and that the same pyrrole was obtained by aldol condensation of D-glucosamine with pyruvic acid. These findings (*Nature*, **176**, 881; 1955) left no doubt on the position in neuraminic acid of the key functional groups and favoured Blix's (1955) rather than Zilliken's (1955) empirical formula of N-acetylneuraminic acid.

The Lobry de Bruyn – van Ekenstein transformation of sugars in all its aspects and side-reactions (formation of deoxyosones) is very logically presented by J. C. Speck. The accumulated results show that these transformations proceed by an enolization type of mechanism and that a common intermediate is formed in the aldose – ketose isomerization and the 3-deoxyosone production. The alkaline degradation of polysaccharides also begins at the reducing end of the molecule with enolization and proceeds stepwise through the anhydroglycose chain. In such a peeling process the reducing end group is liberated from the chain by elimination of the rest of the chain as a glycoxy anion. The released end-group forms an α-dicarbonyl structure which is rearranged by a Cannizzaro type of reaction to yield saccharinates. R. L. Whistler and J. N. BeMiller have cogently summarized this field. The reaction schemes clearly indicate the dependence of the type of saccharinate formed (ordinary, meta- or iso-saccharinate) on the structure of the glycosyl units of the polysaccharide. Incidentally, treatment of unsubstituted N-acetyl-D-glucosamine by mild alkali results in the formation of D(+)-5-dihydroxyethyl-3-acetamido-furan, and not in that of glucoxazoline (p. 305). The life-work of J. W. E. Glattfeld on four-carbon saccharinic acids is reviewed by J. D. Crum.

The story by G. V. Caesar of starch nitrate, the oldest known and industrially the most important starch derivative, reads like a 'thriller'. I. Goodman reports on glycosyl ureides and L. Stoloff contributes a chapter on polysaccharide hydrocolloids of commerce. The important formazon reaction with its implications for the structure of sugar phenylhydrazones and phenylosazones and with its use as a tool for elucidating the structure of polysaccharides is comprehensively described by L. Mester.

It seems most appropriate that the opening chapter is dedicated to the memory of Carl Neuberg, who has made outstanding contributions to many of the topics discussed in this excellent volume.

ALFRED GOTTSCHALK

PRELUDE TO SPACE RESEARCH

Vistas in Astronautics

First Annual Air Force Office of Scientific Research Astronautics Symposium (Co-sponsored with Convair Division, General Dynamics Corporation). Edited by Morton Alperin and Marvin Stern. (International Series of Monographs on Aeronautical Sciences and Space Flight. Division 7: Astronautics Division, Vol. 1.) Pp. xxi+330. (London and New York: Pergamon Press, 1958.) 105*s*. net.

IN February 1957 satellites and space exploration were things of the future, and the organizers of the Astronautics Symposium held in that month at San Diego were at pains to secure serious papers on the subject from recognized scientists, rather than to encourage speculative contributions. Consequently, the title of this book, which provides a record of the papers read at the Symposium, is slightly misleading: most of the papers remain earthbound (if we stretch this phrase to include satellite orbits); only a few flutter off into the depths of space.

The book is divided into six sections of roughly equal length. The first, entitled "Re-entry", includes an excellent paper by C. Gazley describing the deceleration and heating of a body entering a planetary atmosphere from space, and several contributions on the aerodynamics of re-entering space-vehicles.

Part 2, on "Tracking and Communication", includes a detailed description of the 'Microlock' radio instrumentation system for satellites. The third section, on the environment of a space vehicle, has several expert surveys of particular topics, such as F. L. Whipple's paper on the "Meteoric Risk to Space Vehicles" and H. V. Neher's terse 1½ pages on cosmic rays. In Part 4 the possible propulsion systems for space travel are fully discussed. Part 5 is devoted to orbits, and includes a 39-page paper by H. Oberth, on "A Precise Attitude Control for Artificial Satellites". Part 6 is entitled "Human Factors", and covers space medicine and legal problems.

The individual papers in the volume differ greatly in their length, tone, technicality and worth. The book can be recommended for its many good technical papers, most of which have stood the test of time well; but there are a few half-page contributions which scarcely deserve permanent reproduction in book form, and the frontispiece, a full-page photograph of the brigadier-general commanding the Air Force Office of Scientific Research, seems rather out of place in a technical book. D. G. King-Hele

EXPLOSIONS IN SOLIDS

Fast Reactions in Solids

By F. P. Bowden and A. D. Yoffe. Pp. ix+164. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 40*s*.; 7 dollars.

THIS book is a sequel to the authors' earlier (1952) monograph "The Initiation and Growth of Explosion in Liquids and Solids". It deals with subsequent work on the same problems and more particularly with the mechanism by which a crystalline explosive decomposes when subjected to heat, light shock or nuclear radiation. Like its predecessor, the book does not attempt to give a comprehensive treatment of the whole field but rather to focus attention on salient developments in the study of explosives and especially on those areas to which the work of the authors and their colleagues has contributed. In this it is most successful and it is a stimulating and attractive volume.

Chapter 1 is a brief (4 pages) introduction and sketches the plan of the book. Chapter 2, which gives an account (13 pages) of the slow decomposition of crystals, is based mainly on silver azide. Chapter 3 is longer (25 pages) and more diversified. Under the general title of thermal explosions it gathers a varied, though not always clearly organized and interrelated, collection of theory, simple calculation and experiment. It is an important chapter to the remainder of the book, for the ideas of thermal explosion theory outlined here are repeatedly applied in this and subsequent chapters. The importance of a molten zone to reaction propagation is also introduced. In Chapter 4, the structure and stability of the inorganic azides are reviewed (12 pages) in terms of electron sharing between the metal atom and the azide group; this concept is one of the important new points of view this book adopts. Chapter 5 (31 pages) on initiation of explosion by shock is closest in theme to the previous monograph. An account is given of recent work on initiation by impact, flying particles and shock waves, by friction and by ultrasonic vibration. Mechanical initiation is thermal in origin; but 'mechanical' factors such as the disintegration of liquids and solids play a part. Chapter 6 (25 pages) reaches a basically similar conclusion about initiation of explosion by flash photolysis. The azides are again the principal subject and the concepts of Chapters 3 and 4 are applied in interpretation. Decomposition and ignition by nuclear particles and high-energy radiations are dealt with in Chapter 7 (11 pages). High-energy particles provide a convenient method of introducing large amounts of energy into molecularly small regions of the crystals, and the experimental evidence so far is that the activation of a small number of adjacent molecules may not be enough to cause explosion. In Chapter 8 (7 pages) the mysterious, spontaneous explosions which occur during crystallization of lead and mercurous azide are described and discussed. The first part (7 pages) of Chapter 9 on the fast growth of explosion deals with thin films and the deflagrations and "low velocity detonations" which occur. The second part (9 pages), which contains some very striking photographic records, discusses small single crystals undergoing explosive decomposition.

This is the arrangement of the text. Each chapter after the first has its own 'conclusion' summarizing in broad generality the trends the authors feel significant and it is often helpful to read these before their chapters. Perhaps the reader would have been helped still more had the principal subdivisions of the chapters been listed with the contents. The text is prefaced by a useful list of names and formulæ of most of the explosives discussed and followed by a set of eight appendixes which are up-to-date short tables of various properties. There are good author and subject indexes.

It is not the duty of a monograph of this nature which concentrates on recent work in a changing field to supply an extensive background; the appearance last year of M. A. Cook's formidable "Science of High Explosives" helps to meet this need. This book is modern and reliable and the few errors other than trivial misprints that exist, such as the apparent application of le Chatelier's principle to a non-equilibrium process, the occasional use of 'inorganic compound' where 'ionic solid' is intended and of the erroneous $Cu_2(N_3)_2$ and $Au_2(N_3)_2$, may arise from compression and from production of such an up-to-date monograph. Above all, the experimental work from the authors' laboratory has a lucid quality which permits it to speak for itself without laborious argument. Perhaps 'photogenic' is an apter word to do greater justice to the brilliant photographs which have been obtained and which so admirably illustrate the text. Peter Gray

APPLICATIONS OF STATISTICS IN PHYSICS

Statistical Physics

By L. D. Landau and E. M. Lifshitz. (Course of Theoretical Physics, Vol. 5.) Translated from the Russian by E. Peierls and R. F. Peierls. Pp. x+484. (London: Pergamon Press, Ltd., 1958.) 80*s*. net.

IN abandoning the general practice of considering classical statistics, quantum statistics and thermodynamics as virtually separate subjects, the authors have produced a book in which the three have been combined with considerable success. Although no

concessions have been made to the mathematically under-privileged, the importance and significance of the underlying physical principles have not been neglected so that the honours degree student, irrespective of his mathematical attainment, will find much to stimulate his interest in, and to clarify his ideas on, this the most fundamental branch of physics.

The initial chapters are devoted to the establishment of general principles by first laying the statistical foundations, then deriving the principal thermodynamic quantities and relations associated with the macroscopic state and finally obtaining the standard distribution functions, both classical and quantum. Then follow admirable comprehensive treatments of particular applications to closed systems in thermodynamic equilibrium, some examples of which are perfect and real gases, condensed bodies, solutions, chemical reactions, fluctuations and surface phenomena. A chapter on the symmetry of macroscopic bodies could well be omitted as the treatment is too condensed for all but professional crystallographers, and for them it is unnecessary.

There are some weaknesses in the general presentation. The style is occasionally laboured and an improvement in the continuity could be effected by including in the text the material added in numerous footnotes. Further, it is surely unnecessary to derive first a dimensionless expression for entropy into which later must be inserted Boltzmann's constant. Again, after the excellent exposition of the basic statistical principles it is surprising that reference should be made to both the specific heat and the Gibbs free energy per molecule. Finally, the authors depart in several instances from the conventional in their use of thermodynamic terms; in particular, by "adiabatic" they always mean "reversible adiabatic".

H. STEEPLE

THE GREAT LAKES

Geology of the Great Lakes

By Prof. Jack L. Hough. Pp. xviii+313. (Urbana, Ill.: University of Illinois Press, 1958.) 8.50 dollars.

FORTY-FOUR years have passed since Leverett and Taylor published their classic work on the history of the Great Lakes. During much of the last twenty-seven of these Prof. Hough has been engaged on studies of the various aspects of this great group of inland waters. There has been a growing need for a summary of the large amount of work that has been accomplished in the interval.

The book is divided into two parts. The first deals with the topography and hydrology of the present lakes and the deposits on their floors, as well as the pre-glacial and glacial history of the region in general terms. The latter is inevitably a simple outline which forms the basis for the more important second part of the book.

Part 2, comprising rather more than half the book, deals with the history of the stages of evolution of the lakes as bodies of open water fluctuating in extent, with changes in the position of the oscillating front of the ice sheet to the north. The series of outlets of the lakes to the Mississippi, to the Mohawk and Hudson valley, to Lake Erie and the St. Lawrence, and to the St. Lawrence via the north-east corner of Lake Huron and the Ottawa River came into action repeatedly. The story now unfolded is substantially more complicated than the account of Leverett and Taylor, and the work is very much better documented, in consequence of the research by many workers, including substantial contributions from the author himself. This applies particularly to revised and more detailed correlation of events over the vast area involved.

Particularly noteworthy parts of the book are the detailed but concise critical assessments of the evidence on which correlation is based, a valuable correlation chart based with an absolute dating scale on carbon-14 measurements, and among the many text figures 23 diagrams, summaries of the successive stages in the fluctuation of the extent and outlets of the lakes throughout late and post-glacial time. The large-scale southerly tilt of the area consequent on the isostatic rise as a result of the progressive de-glaciation of the area introduces complications in the history in the correlation of shore lines, and this is accentuated by the erosion of considerable lengths of the old beaches during later stages of the history of the lakes.

The author is to be congratulated on a major contribution to late-glacial geology of the region. The text figures are clearly produced and there is an excellent bibliography.

S. E. HOLLINGWORTH

ANTING

Phoenix Re-born

By Dr. Maurice Burton. Pp. 224+16 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1959.) 25*s*. net.

FOR many years anting in birds has held considerable fascination for students of bird behaviour. So, too, has the myth of the Phœnix, and when Maurice Burton saw a tame rook disporting himself on a heap of burning straw it led to an association of ideas which was ultimately responsible for the production of this book. After thorough exploration of the Phœnix legend, Burton carried out experiments with his tame rooks and a pet jay to determine their reactions to certain substances and to heat. He also examined the literature to see whether records of bird and other animal behaviour might reveal anting incidents which had been unidentified. Eventually Burton reached certain conclusions which show a clear connexion between Herodotus's account of the Phœnix and the anting of birds.

One thing is common to all the substances which cause the anting posture: this is heat or the impression of heat. In this remarkable book Burton compares the reaction of birds to different substances, examines the theories of anting and comes to the conclusion that anting must be regarded as a posture adopted in moments of unusually intense excitement. This may be stimulated autochothonously or through the agency of an external stimulus producing heat or the impression of heat in the mouth. Ant-bathing and thermophily are also shown to be closely related to anting proper and all these are related to such habits as the self-anointing of hedgehogs, the effects of catmint and other odorants on carnivores, as well as numerous idiosyncrasies of behaviour among individual birds and mammals, not excluding man himself.

The charm of the book lies not only in the emergence of a new theory to an old puzzle; the telling also stamps "Phœnix re-born" as an ornithological thriller of outstanding interest.

T. H. HAWKINS

Introduction to Functional Analysis

By Prof. Angus E. Taylor. Pp. xvi+423. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 100*s*. net.

LINEAR functional analysis arose partly from Hilbert's theory of space of an infinity of dimensions and its axiomatic formulation by John von Neumann, and partly from Banach's development of Fréchet's work on abstract spaces. Good recent books include those by Zaanen and by Riesz and Nagy. Prof. Taylor's introduction will not displace these books, but can serve as a useful survey of basic methods. In lecture form, the material has been tried out on several graduate courses in the United States, and hence is particularly helpful in the early chapters. In the first, the algebraic formulation is kept clear of topology; linear spaces, operators and functionals are defined and illustrated by a wealth of examples of each type, so that the novice is gently helped to surmount his initial difficulty of forming some concrete idea of these abstract concepts. The second chapter is a reference section on topology; then in the third, the linear space and the topological space are related to provide the concept of the linear topological space, again with many carefully detailed instances of such spaces. The reader who studies these three chapters closely will be rewarded with a firm grasp of fundamentals and should then cope readily with the somewhat increased pace of the later chapters giving the general theory of linear operators, spectral analysis and the standard results for self-adjoint, normal and unitary operators. The old-fashioned analyst will be pleased to see contour integration employed in the spectral theory, a method much emphasized in some of Taylor's own papers. The final chapter, on integration and linear functionals, is intentionally only a sign-post to further reading in this field. The book should be particularly valuable to those who need to get some knowledge of the unifying and co-ordinating power of this potent theory without having to make a specialist's study of it. T. A. A. Broadbent

The Birds of the Palearctic Fauna

A Systematic Reference. Order Passeriformes. By Dr. Charles Vaurie. Pp. xii+762. (London: H. F. and G. Witherby, Ltd., 1959.) 105*s*.

IT has been claimed that birds are systematically better known than any other class of animals, but even for the relatively familiar Palæarctic region a new 'base-line' has become desirable. This is here provided in respect of the passerine birds—a second volume is now being prepared to cover the rest—in succession to the corresponding part of Hartert's "Die Vögel der paläarktischen Fauna" of 1903–32. Unlike Hartert, the present author does not give descriptions of species, but only the main points distinguishing one sub-specific form from another; synonymies are brought up to date rather than repeated in full. English names are given for all species, with the French and German equivalents where these exist.

The present less-rigid outlook on intraspecific systematics is reflected in the emphasis placed on the 'clinal' nature of much of the geographical variation, and previously described races which the author regards as mere stages on a cline or as otherwise unsatisfactory are relegated to the synonymy; races which the author accepts are graded as "well" and "moderately well" differentiated but are otherwise given identical treatment. Of special value are the detailed accounts of the ranges of all forms, and these are usefully reinforced by information about the habitat of each species. There are also brief indications of extra-limital distribution and of the existence of extra-limital races, the latter being mentioned by name when not too numerous. There are doubtless some points on which other experts may differ, but the volume can be welcomed as an up-to-date authoritative work of reference on the systematics and zoogeography of the palæarctic passerine avifauna. Landsborough Thomson

The Open Sea—Its Natural History

Part 2: Fish and Fisheries, with Chapters on Whales, Turtles and Animals of the Sea Floor. By Sir Alister Hardy. (The New Naturalist: a Survey of British Natural History.) Pp. xiv+322+48 plates. (London: William Collins, Sons and Co., Ltd., 1959.) 30*s*. net.

THOSE who enjoyed Sir Alister Hardy's first book on "The Open Sea" will also enjoy his second, for it has the same virtues: it is written with infectious enthusiasm and with a wide knowledge of fish and fishermen. He has sailed in both the old and the new *Discovery*, in trawlers on fishing trips and in fisheries research vessels of many lands, so that he brings a vivid sense of actuality into his writing.

Beginning with a brief résumé of the fundamentals of life in the sea, the author goes on to describe what a fish is and how it lives and moves. Then follow chapters on particular fish and fisheries. The herring is given pride of place with a short account of its history and of the research work on it right up to the present day. After two chapters on the bottom fauna, we return to fishing with descriptions of different types of gear and chapters on plaice, elasmobranchs and gadoids. The over-fishing problem is not neglected, and indeed in many places throughout the book the author shows how the knowledge we already have could be applied to improve or increase the fisheries. He ends with the plea that the division of the North Sea into northern and southern spheres of research should be abandoned in favour of a united effort covering the whole area.

There are chapters also on the animals of the ocean floor, on parasites, particularly of fish, on reptiles (not omitting the sea-serpent) and on marine mammals.

No attempt has been made to cover the systematics or physiology of fish. This is a natural history of the creatures living in the open seas around Britain and there can be few who will read it without learning something new and interesting.

Mention must be made of the excellent illustrations. Many of the plates are reproductions of the author's own delightful water colours. The photographs, many by Dr. D. P. Wilson, are outstanding and include some wonderful shots of whales and courting fish. S. M. Marshall

Flora of Peru

By Rogers McVaugh. (Field Museum of Natural History: Botanical Series, Vol. 13, Part 4, No. 2.) Pp. ii+569–818. (Chicago: Field Museum of Natural History, 1958.) 3.75 dollars.

THIS part continues the Flora of Peru with the account of the difficult family, Myrtaceae, contributed by Prof. Rogers McVaugh, of the University of Michigan. The bulk of the species belongs to two large genera, *Myrcia* and *Eugenia*. The author is to be congratulated on his carefully prepared keys and long specific descriptions. There are no illustrations.

SPECTROSCOPIC IDENTIFICATION OF ALPHA-EMITTING NUCLIDES IN BIOLOGICAL MATERIAL

By Prof. W. V. MAYNEORD, C.B.E., and C. R. HILL

Physics Department, Institute of Cancer Research : Royal Cancer Hospital, London, S.W.3

In connexion with a programme aimed at the identification and measurement of the radioactivity of the human body and its environment[1–4], an attempt has recently been made to undertake spectral analysis of the alpha-activity of normal biological materials. The most satisfactory general method of analysing alpha-activity is to measure the size of the individual pulses due to electrons which are produced when the alpha-particles are made to spend their full energy on ionizing a free electron gas. In the past, attention has been directed largely to materials having moderately high specific activity and the gridded parallel plate ionization chamber has been the instrument most commonly used[5–8]. This type of chamber is not, however, suitable for the analysis of materials of very low activity, for which a large source area and a low background counting-rate are essential. In order to provide a large source area, Lonati *et al.* have designed an instrument in which the source material is spread on a large metal sheet, which is afterwards rolled to form the outer member of a cylindrical electrode system, a grid being situated between the emitter and collector[9]. The background counting-rate of their instrument is still appreciable and due, in part at least, to the large areas of metal surface exposed to the counting volume, and to contamination on the grid wires. The use of a cylindrical or spherical arrangement can, however, largely obviate the need for a grid in overcoming line broadening due to positive ion effect[10] and has been exploited successfully by Ghiorso in an early instrument[11]. If, in a gridless chamber, the sensitive volume is surrounded by material having very low alpha emission, the background counting-rate corresponding to alpha-particle energies may be made very small. Such an instrument has been built by us at the Institute of Cancer Research : Royal Cancer Hospital and has proved to be capable of analysing the alpha-activity of a wide range of normal biological materials.

Description and Performance of the Instrument

The instrument consists essentially of two concentric cylindrical electrodes of length 53 cm. and radii 15 and 0·2 cm., respectively. The material to be analysed is mounted on the metallized surface of a sheet of aluminized cellulose acetate, lining the inner surface of the outer electrode, and a potential of minus 3 kV. applied relative to the inner, collecting electrode. The electrode system is enclosed in a vacuum-tight steel tank containing a mixture of 90 per cent argon and 10 per cent methane at atmospheric pressure. Under these conditions the theoretical spectral line-width due to positive ion effect is 210 keV. at 5·5 MeV. The line-width obtained in practice is rather greater as a result of contributions from amplifier noise and self-absorption in the uncollimated source. As a result of mounting the source on aluminized cellulose acetate film (which itself has a surface emission of about 3 alpha-particles per hr. per 1,000 cm.^{2} compared to stainless steel 100, brass 100, aluminium 150) and of the relatively small area of other surfaces exposed to the counting volume, the background counting-rate due to surface emission is only 20 counts per hr. in the energy-range 4–9 MeV. and for a useful source area of 4,000 cm.^{2}. Due, however, to the presence of radon, originating, it is believed, mainly from the surface of the pressure vessel (which was originally built for another purpose and is impossible to clean satisfactorily), the actual background is somewhat higher than the above figure. By continuously circulating the chamber gas over charcoal cooled in a solid carbon dioxide–alcohol bath, the radon background, which appears as a three-line spectrum of radon, radium A and radium C′, is maintained constant at 70 counts per hr., giving a total background of 90 counts per hr.

The ionization chamber is used with *EKCO* 1049 *B* head and main amplifiers and a *CDC* 100-channel pulse-height analyser. This combination provides good stability of recording and, when purity of the chamber gas is maintained by continuously flowing over calcium turnings at 350° C., overall drift can be kept within 100 keV. over a period of several days.

Preparation of Sources

The sources, which normally consist of a partially insoluble ash of uncertain chemical composition, are prepared by grinding (by hand or in a ball mill) followed by spraying in the form of a suspension in water on to the cellulose acetate sheet, previously wetted with dilute 'Teepol' solution. A thin layer of sodium silicate solution is usually sprayed on top of the film so formed (0·03 mgm./cm.^{2} sodium silicate) to act as an adhesive[12]. By this process it is possible to prepare sources which under a microscope appear to consist mainly of particles of about one micron diameter, spread with good uniformity.

Results

As illustrations of the use of this technique, spectra obtained with our equipment are shown in Figs. 1–4.

A popular breakfast cereal, stated to contain "100 per cent whole wheat" and having a total specific alpha-activity of 32×10^{-12} c. per gm. of ash (Fig. 1), evidently contains two long-lived alpha-emitters, radium-226 and thorium-228 (RdTh), and their daughters. Most of the radon-222 escapes from the thin source and is removed from the system by the radon trap, so that it and its daughters do not appear

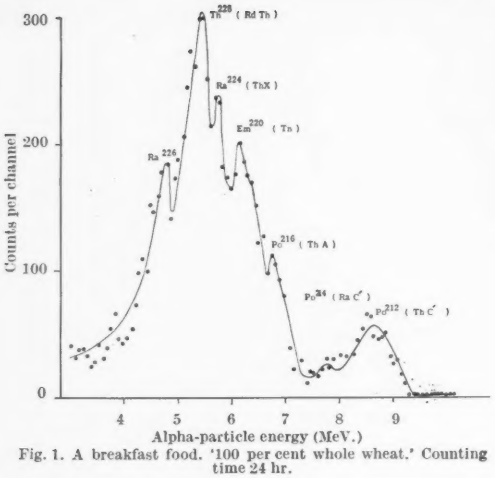

Fig. 1. A breakfast food. '100 per cent whole wheat.' Counting time 24 hr.

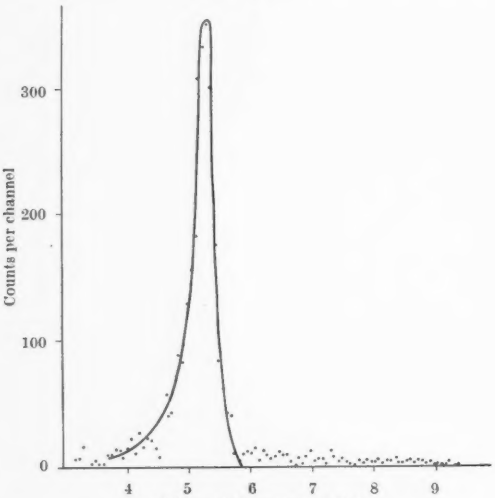

Fig. 2. Grass ash. Total specific alpha-activity $6{\cdot}4 \times 10^{-12}$ c./gm. Counting time 36 hr.

from the spectrum to be in equilibrium with radium-226. Uranium-238 and thorium-232 are absent and the thorium-228 must therefore be presumed to originate from radium-228 (MsTh 1) rather than by metabolic uptake of the element thorium. A similar spectrum, but showing relatively higher radium-226, has been obtained for Brazil nuts, which are known to have very high alpha-activity[3]; these results have been published elsewhere[4].

Measurements have been made in these laboratories of the total alpha-activities of grass samples taken from various localities[13], and values found in Great Britain have ranged from 1·0 to 170 × 10^{-12} c. per gm. of ash. Spectra of the form shown in Fig. 2 have been obtained from all the grass samples that we have analysed so far, which have been collected from several different parts of the country. It will be seen that this spectrum is of different form from that of Fig. 1, most of the activity being concentrated in a small energy-range. While it is not possible from our spectral evidence alone to decide with confidence whether the nuclide concerned is polonium-210 (5·30 MeV.) or plutonium-239 (5·14 MeV.), evidence from chemical analysis and from the build-up of activity with time, after ashing at 500° C., has established that the nuclide is, in fact, polonium-210 in the presence of lead-210 (RaD). From this spectrum we conclude that polonium-210 accounts for some 90 per cent of the total alpha-activity of the grass ash.

In view of the known tendency for the kidney of several species to take up polonium[14,15], we have examined the kidney of a sheep that had been grazed in the district from which the grass sample

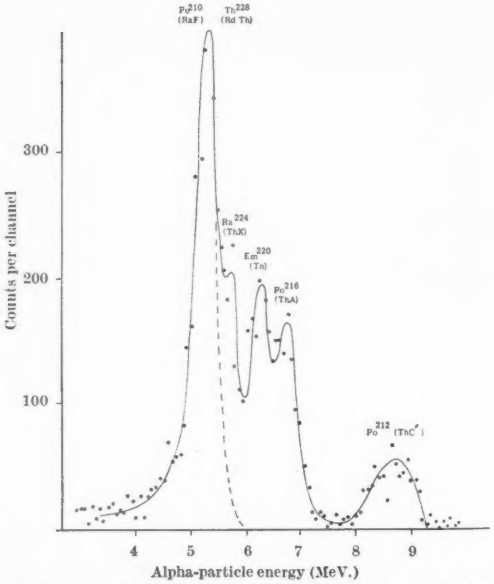

Fig. 3. Sheep's kidney. Total specific alpha-activity $6{\cdot}0 \times 10^{-12}$ c./gm. ash. Counting time 48 hr.

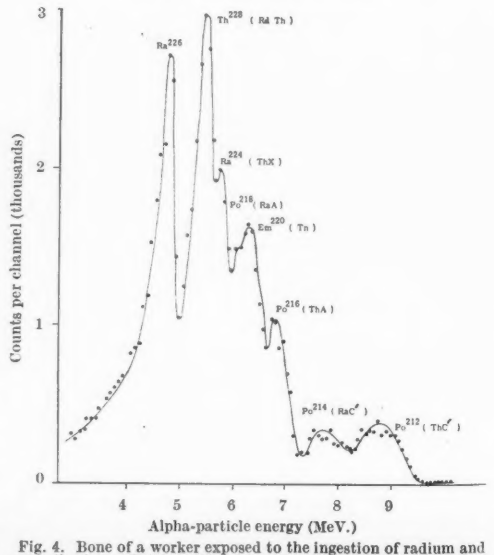

Fig. 4. Bone of a worker exposed to the ingestion of radium and mesothorium. Total specific alpha-activity 214×10^{-12} c./gm. ash. Counting time 24 hr.

of Fig. 2 was obtained. The total specific alpha-activity was $6 \cdot 0 \times 10^{-12}$ c. per gm. of ash (ash content of wet kidney 1·1 per cent) and the spectrum (Fig. 3) shows that about half the total is due to thorium-228 and its daughters, an observation confirmed by an independent method of estimating thorium series nuclides[2]. In addition, there is a single line of the same energy as that appearing in the grass, presumably again polonium-210. The presence in the kidney of thorium-228 is interesting in view of the absence of thorium-232 and radium-226, although the latter is clearly present in a spectrum taken of the bone of the same animal. The explanation would appear to be that radium, but not thorium, is absorbed by the sheep from its environment and that thorium-228 originates within the sheep by decay of radium-228, being afterwards transported and fixed in the kidney.

The spectroscopy of normal human bone is beyond the capacity of our present equipment, but interesting results may easily be obtained for the bone of those having radium burdens of the order of one-tenth of the maximum permissible level. Fig. 4 shows the spectrum of the bone of a worker who had been exposed to the ingestion of both radium-226 and radium-228 and whose body burden of the former isotope was estimated[2] at $5 \cdot 9 \times 10^{-8}$ c. The presence of radium-226 and of radium-228 with its daughters is clearly demonstrated.

Potentialities of the Method

It seems clear that this type of alpha-ray analysis will prove of great value in the study of the radioactivity of biological materials. We are therefore constructing equipment that should be capable of analysing, with improved resolution, the ash of most living tissues.

We are greatly indebted to our colleague, Dr. R. C. Turner, with whom we have had many fruitful discussions concerning the interpretation of these spectra. Our thanks are due to Mr. J. O. Crookall for the chemical evidence concerning polonium and to Mr. S. P. Newbery for invaluable help with the electronic equipment. We are also indebted to Dr. U. Facchini and his colleagues of C.I.S.E., Milan, who kindly analysed a number of samples for us in their gridded parallel plate chamber before our own instrument was completed.

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THE OHIO STATE UNIVERSITY 360-FT. RADIO TELESCOPE

By Prof. JOHN D. KRAUS
Ohio State University

FOR some years mapping of the radio sky has been a principal activity at the Ohio State University Radio Observatory. Since it was anticipated that this would also be the case if a larger telescope became available, consideration was given some years ago to a telescope design especially suited for mapping work which would provide the largest possible aperture per unit cost consistent with large sky coverage. The design evolved consists of a fixed standing parabola with a flat reflector which can be tilted to deflect the celestial radiation into it. The general arrangement is shown in Fig. 1. Since the parabola is fixed and supported directly from the ground, a minimum of structure is required. The only moving part is the flat reflector, which is pivoted at ground-level and is required to move through only one-half of the range of declination covered. Although primarily a meridian transit instrument, east–west movement of the feed antenna can provide a small measure of tracking in hour angle. This is not essential, however, in most mapping work.

Scale Model

Experimental work on the design began in 1953 when Robert T. Nash constructed a scale model of the telescope, as part of his thesis work toward a master's degree at the Ohio State University. The parabola of the scale model measured 12 ft. in horizontal length while the wave-length of operation was 1·25 cm. By scaling both the physical size and the wave-length in this manner, antenna patterns can be measured that will duplicate those of the full-size system[1]. Specifically, the system duplicated is a telescope with a parabola 2,000 ft. by 200 ft. operating at 2 metres wave-length or a telescope with a parabola 700 ft. by 70 ft. operating at a wave-length of 70 cm. A photograph of the model is shown in Fig. 2.

Antenna patterns measured by Nash agreed closely with calculated values[2,3]. In fact, the performance of the model was so satisfactory that Nash used it as an actual radio telescope for many observations of the Sun and Moon at a wave-length of 1·25 cm.[4].

Construction of the Full-Size Unit

In 1954 a request was made to the United States National Science Foundation for funds to construct a standing parabola radio telescope with a flat reflector of adjustable tilt, the parabola to be 720 ft. long by 70 ft. high. The minimum wave-

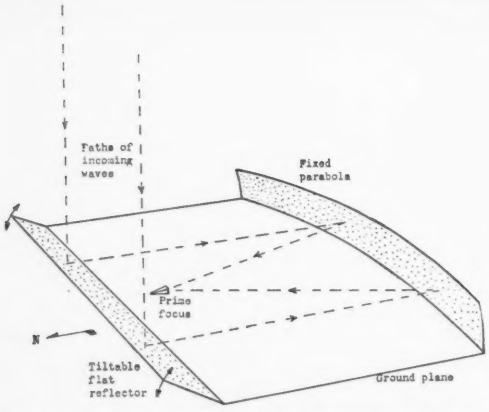


Fig. 1. Principle of operation of the standing parabola radio telescope with flat-sheet reflector. The declination angle of reception is changed by tilting the flat reflector while scanning in right ascension is accomplished by the Earth's rotation

length of operation was to be about 70 cm. and the dimensions were deemed sufficient to provide a significant full-scale test of the design. In 1956 a grant was received from the National Science Foundation for half the amount requested for a parabola 720 ft. by 70 ft. As a result, the plans were modified to build the central half of the telescope so that the parabola would be 360 ft. long by 70 ft. high and the flat reflector of adjustable tilt also 360 ft. long with the possibility that outer sections might be added at some future date. At the suggestion of the Radio Astronomy Panel of the National Science Foundation, the original plans were also modified to make the telescope operate at the hydrogen line (21 cm. wave-length). To maintain surface tolerances at this wave-length required a structure with several times as much steel as in the original design, with a corresponding increase in cost. Two subsequent grants by the National Science Foundation in 1957 and 1958 have brought the total funds provided for the construction of the telescope close to 250,000 dollars.

A sketch of the final design of the telescope is shown in Fig. 3. This sketch is substantially correct, the main discrepancy being that the actual system for elevating the flat reflector uses a winch arrangement instead of a hydraulic cylinder as suggested in the sketch.

The Ohio Wesleyan University provided a 20-acre site for the radio telescope situated about 4 miles from Delaware, Ohio, and near the Perkins (optical) Observatory. The new radio observatory location is known as the Ohio State–Ohio Wesleyan Radio Observatory.

Construction on the telescope began in 1956 with work on the parabolic reflector. The mechanical design of the structure has been the responsibility of Robert T. Nash and the construction also has been carried out under his supervision. The construction crew has consisted of about ten men, most of whom have been Ohio State University students who have worked on the telescope on a part-time basis. The parabola was completed in 1958 and work started on the flat reflector. A view of the completed parabola is shown in Fig. 4. At the time of writing (July) the foundations for the flat reflector are mostly in place and sub-assemblies of the steel structure nearly completed. One section of the flat reflector has been assembled and preliminary tests of the hoisting and locking system carried out.

Specifications

The parabola (360 ft. × 70 ft.) is a section of a paraboloid of revolution with axis coincident with the ground plane and passing through the prime focus. The focal distance is 420 ft. The aperture area is 25,200 sq. ft. or about 0·6 acre. This area is equal to that of a circular aperture parabolic dish antenna nearly 180 ft. in diameter. The reflecting surface of the parabola consists of vertical copper-clad steel wires 0·081 in. in diameter spaced 1 in. between centres. The entire wire-supporting structure of the parabola is hung from the main parabola framework by adjustable brackets in order to facilitate adjustments of the parabola surface if required. The ultimate surface deviation of the parabola is expected to be less than $\frac{1}{2}$ in.

The flat reflector is constructed in movable units 20 ft. wide (east–west) by 100 ft. long in the slant direction. Under normal loading conditions the maximum deflexion of this structure from a flat surface is expected to be of the order of $\frac{1}{4}$ in. Such movable units are to be mounted with a 40-ft. spacing between centres. Each unit is to be equipped with an individual 3 h.p. electric winch and fast-acting pneumatically operated brake and lock. The winch elevates or lowers the flat reflector unit so that the declination may be changed at a rate of about 5° per min. Twenty-foot beams hinged on each end

Photo: Dept. of Photography, Ohio State University

Fig. 2. Photograph of scale model built to test the design. The standing parabola is at the right and the flat sheet reflector at the left, with the horn feed antenna at the prime focus just to the right of the base of the flat-sheet reflector

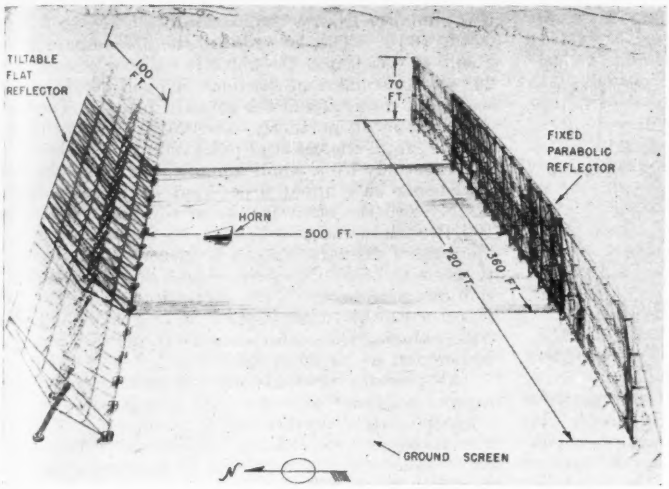


Photo : Dept. of Photography, Ohio State University

Fig. 3. Sketch of the standing parabola radio telescope with flat-sheet reflector being built at the Ohio State University. The central section of the telescope, shown in heavy lines, is the part now under construction, with the end sections, in phantom view, showing possible future additions

will bridge the space between movable units. The actual reflecting surface will consist of the same type of wire with the same spacing as used in the parabola. Although each movable unit of the flat reflector is itself rigid, the flat reflector as a whole is non-rigid since the hinged connecting beams permit each unit to be moved a couple of degrees independently of the adjacent units. The surface of the flat reflector will be monitored with an optical telescope placed at a point on the axis of rotation (along the base of the flat reflector) west of the reflector, and units adjusted individually until the desired declination of all units is attained.

The steel in the parabola and flat reflector has a total weight of about 300 tons while the concrete in all the foundations totals about 1,200 tons. The horizontal ground plane between the parabola and the flat reflector will consist of thin aluminium sheet a few thousandths of an inch in thickness, on flat 'Poly-foam' slabs floated on the surface of a water-filled pond. It is anticipated that the surface of this ground plane can be maintained flat to less than $\frac{1}{2}$ in.

The antenna feed system at the prime focus will be situated on a peninsula covered with conducting sheet which extends south from the base of the flat reflector into the pond. At the higher frequencies horn antennas will be used as was done with the scale model (see Fig. 2), while corner reflectors will be used at lower frequencies. It is planned to operate the telescope at wave-lengths from 15 cm. to 15 metres, a range of 100 to 1. The polarization is vertical. The presence of the horizontal ground plane, which acts as an electrical image plane, reduces the required height of the feed antenna to one-fourth of the value which would be needed if no ground plane were present. Owing to the large horizontal dimension of the standing parabola, the required horizontal dimension of the feed antenna is also small. As a result, the aperture blocking or area of obstruction presented by a single feed antenna is very small, amounting in a typical case to only about one-tenth of one per cent of the aperture of the parabola. Accordingly, a multiple feed can be employed without objectionable blocking of the aperture to provide simultaneous operation over a wide range of wave-lengths. It may even be possible by means of a multiple feed to construct a rudimentary radio camera having as many picture elements as primary feed antennas.

The fact that the feed point is at ground-level completely eliminates the problem of supporting the feed antenna and maintaining its alignment, a problem present in all steerable telescopes. Furthermore, there is almost no limitation to the weight and complexity of the equipment placed at the feed point, so that feed cable losses are eliminated and low-noise amplifiers of the maser and parametric type can be used to best advantage.

At the highest frequency of operation (15 cm. wave-length) the half-power beam-widths of the telescope antenna will be 0·1° in right ascension by 0·5° in declination. (Initially the beam-width in right ascension at 15 cm. will be twice this value, since only the central 180 ft. of the parabola has a reflecting wire spacing of 1 in. and only this portion will be useful at 15 cm. The outer portions have a wire spacing of 3 in. and at longer wave-lengths the entire parabola can be used. However, initially only the central 260 ft. of the flat reflector will be completed. These modifications, which were necessitated by a lack of funds, will somewhat hamper initial

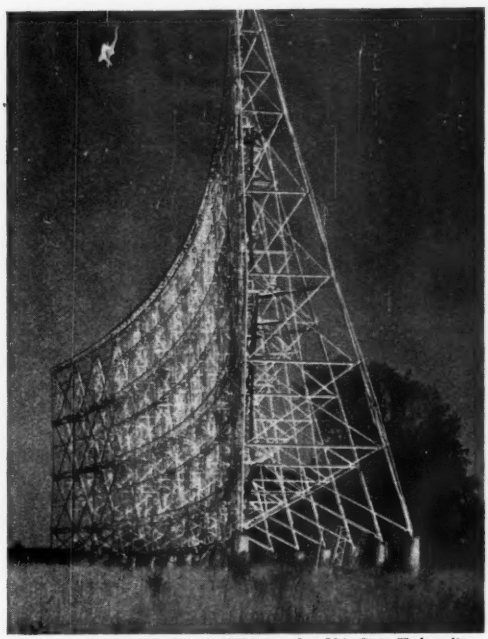


Photo : Dept. of Photography, Ohio State University

Fig. 4. View of the completed 360-ft. parabola from the west

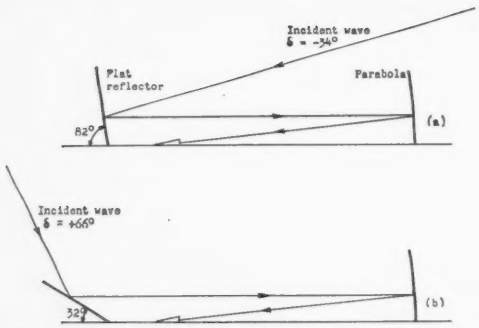


Fig. 5. Diagrams showing extreme positions of the flat reflector and corresponding wave or ray paths

operation of the telescope, but it is hoped that these deficiencies can be remedied at an early date.) This fan beam from the antenna has the same area resolution as a symmetrical pencil beam with a half-power beam-width of about 0·2°. However, the fan beam has the advantage over the pencil beam of reducing the time required for a complete scan of the sky by a factor of about 2·5, and also of providing twice the resolution in the direction in which the sky is scanned. A fan beam is also valuable for the reason that it differs in shape from the pencil beam typical of most steerable dish antennas. Thus, comparisons of source and background surveys made with beams of different shape are valuable in detecting spurious effects, since beams of different shape are, in general, subject to different aberrations.

Although no tracking ability is required for most sky-mapping work, a small measure of tracking can be provided in the new telescope by some east–west movement of the feed antenna. Tests of the displacement of the feed antenna on the scale model showed that tracking of sources in hour angle may be possible for at least 10 min. in time at the highest frequency of operation and for more than 1 hr. at lower frequencies. With vertically polarized feed antennae the electric field vector is perpendicular to the horizontal ground plane, so that the intensity along the ground plane can be a maximum. Under these conditions the telescope is most efficient and operation is restricted to vertical polarization by providing only vertical wires in the reflecting surfaces of the standing parabola and flat reflector.

The flat reflector is designed to tilt to angles between 32° and 82°, as illustrated in Fig. 5. A motion of the flat reflector through 50° (from 32° to 82°) results in a motion of the antenna beam through twice this value, or from a declination of 66° N. to 34° S. (total 100°). The latitude of the telescope site is about 40° N. Since the galactic equator is at about 29° south declination, the telescope will be useful for studies of the region of the galactic nucleus. The fact that the most northerly observable declination is 66° (24° from the celestial pole) reduces the sky area coverage only by a small amount, the unobservable area being only about 6 per cent of the observable sky. Since the slant height of the flat reflector is 100 ft., while the parabola is 70 ft. high, the full aperture of the parabola can be utilized at all declinations south of 40° N. At the most northern declination of operation (66°), the vertical height of the flat reflector will be 76 per cent of the height of the parabola, reducing the useful aperture of the telescope by 24 per cent under these conditions.

The primary or feed antenna radiation will be tapered in order to reduce the minor lobes of the telescope beam pattern to a minimum. This is important in eliminating spurious responses or ghost sources. An important characteristic of the design is that signal pick-up from the ground is minimized, the telescope antenna beam pattern being always directed skyward with the parabolic and flat reflectors providing a measure of shielding from interfering terrestrial signal sources.

The fact that the main part of the telescope has only one moving part, the flat reflector, the position of which can be accurately controlled, means that it will be possible to measure positions of celestial sources to a high precision and with good repeatability.

Conclusion

The new Ohio State University telescope will be an experimental working model of the standing parabola tiltable flat reflector design which should provide useful information for the construction of similar telescopes of even larger size. It is hoped that the telescope will be completed during 1960, at which time a programme of sky-mapping will be initiated that will cover a wide range of frequencies. More detailed sky maps and more accurate spectra of radio sources will be objectives of the surveys. Instrumentation for hydrogen line observations is also to be installed, and observations conducted of the distribution of neutral hydrogen in our galaxy.

[1] Kraus, J. D., "Antennas", 485 (McGraw-Hill Book Co., Inc., New York and London, 1950).
[2] Nash, R. T., master's thesis, Ohio State University (1955).
[3] Kraus, J. D., and Nash, R. T., Ohio State University Radio Observatory Report No. 5 (1955).
[4] Kraus, J. D., Ko, H. C., Nash, R. T., and Stoutenberg, D. V., *Astro. J.*, **61**, 182 (1956).

RADIOCARBON DATING

CONTRIBUTIONS were made by representatives of each of the three laboratories in England which are actively engaged in radioactive dating to a joint session of Sections A (Physics) and H (Anthropology and Archæology) of the British Association at the recent meeting at York. They combined to provide a picture of the basis of the method and its limitations, the trend of future development in instrumentation, and the capabilities of the method as applied to individual problems in the late Quaternary history of the British Isles.

In reviewing the basis of the method of radiocarbon dating, Mr. H. Barker, of the British Museum Research Laboratory, was concerned with the difficulties which had sometimes arisen as a result of the lack of common ground between the archæologist and the physicist. Lack of familiarity with statistical concepts and misunderstandings as to the nature of radioactive decay had led to many misconceptions and the validity of the method had been questioned on wrong premises. The method depends on the fact, predicted and verified by Libby, that the radio-

active carbon isotope of mass 14 (known as radiocarbon or carbon-14) is being continually created in the upper atmosphere as a result of the action of cosmic rays. Consequently it is distributed throughout the world-wide carbon-exchange reservoir which comprises the atmosphere, the oceans, and all plant and animal life. Libby produced sound theoretical argument, backed by practical measurements, for assuming that the carbon-14 is evenly distributed throughout the exchange reservoir and that the level of radioactivity due to this cause has remained the same for many thousands of years. This assumption is fundamental to radiocarbon dating; when an organism dies it is cut off from the exchange reservoir, the possibility of it replenishing its carbon-14 by vital processes ceases, and its store of carbon-14 diminishes at a rate determined only by the half-life (about 5,600 years). One can therefore calculate the time which has elapsed since it was alive, from a measurement of its residual carbon-14 activity, provided that one can assume that its original activity was the same as that of a reference sample which has been recently removed from the reservoir. The measurement is exceedingly difficult, and limitations in accuracy, imposed by statistical fluctuations in the measurement of radioactivity, result in an error term being associated with each radiocarbon date. The correct interpretation of the significance of this error-term requires some familiarity with statistical concepts, and lack of appreciation of this has led to misunderstandings.

In the ten years which have elapsed since Libby announced his first successes, there has been a revolution in instrumentation. Nowadays, the measurement of radioactivity can be made to a much higher accuracy, and the question arises as to whether the basic assumption of the method still holds good at this new level of accuracy. In fact, it seems that a number of minor effects can combine to limit the accuracy. Craig showed that isotopic fractionation in plants can result in fluctuations of up to $\pm$ 1 per cent in carbon-14 activity from the mean value. This corresponds to an error of $\pm$ 80 years. Fortunately, it is possible to apply corrections for this effect based on mass-spectrometric measurements of the ratios of the other carbon isotopes in the sample and the standard. Systematic errors, mainly due to differences in 'recent' standards, have caused difficulties in comparing results between different laboratories. In most cases, the errors are quite small, but steps are now being taken to eliminate these differences. Very recently, de Vries has shown that the level of activity in the exchange reservoir has suffered cyclic changes of about $\pm$ 1 per cent during the past 500 years. So far as one can see at present, this effect definitely limits the accuracy obtainable in dating to about 100 years.

Apart from these theoretical limitations, it must not be forgotten that the choice of sample plays an important part in the real accuracy obtainable. The archæologist has to relate the death of an organism (which is what is actually measured) to an event in which he is interested. The environment of the sample is not unimportant, the possibility of sample contamination must not be overlooked, and suitable laboratory treatment applied when necessary to remove contaminating materials such as rootlets and humic acids.

Mr. W. J. Callow, of the National Physical Laboratory, also referred to the factors which limit the accuracy of the method, but pointed out that, despite these limitations, the radiocarbon method remains a very valuable technique for chronological studies in archæology, geology, botany, oceanography and allied fields. There are now nearly forty laboratories distributed throughout the world which have been, or are, currently engaged in this form of dating. Some time ago, it was realized that there was a need for a dating service to be made generally available to workers in Great Britain. The laboratories at the Botany School, Cambridge, and the British Museum were occupied in the main with their own programmes, and it was considered appropriate that the new service should be set up at the National Physical Laboratory.

The instrumental difficulties are considerable in that the measurement is concerned with levels of radiocarbon concentration ranging from one part in a million million down to zero. In the case of recent carbon, this corresponds to the breakdown of about fifteen carbon-14 atoms per min. per gm. of carbon. Detecting and recording these disintegrations requires special techniques due to the low energy of the beta-particles and the low counting-rates involved.

In all methods, the first process involved consists of converting the sample to carbon dioxide, either by combustion, in the case of organic material, or by acid treatment, in the case of carbonates. In Libby's original method the carbon dioxide was reduced to solid carbon which had to be placed inside a counter because of the low beta-particle energy. Due to the low efficiency of the counter under these conditions and the possibility of contamination with radioactive fall-out and naturally occurring radon, this technique has now been abandoned.

Both de Vries in Holland and Fergusson in New Zealand have shown that carbon dioxide itself, if sufficiently pure, can be used as the operating gas in a proportional counter, and this technique is being adopted at the National Physical Laboratory. As little as one part per million of electronegative impurity such as oxygen or oxides of nitrogen in the carbon dioxide can prejudice the reliable operation of the counter, and hence the accuracy of the measurement. The gas preparation equipment at the National Physical Laboratory is therefore designed to produce carbon dioxide of an extremely high degree of purity.

Carbon dioxide is not the only possible counter filling; methane and acetylene are in use in some laboratories. Both involve rather more preparatory work, but they are more tolerant of the presence of impurities. Acetylene has the advantage of having two atoms of carbon in its molecule, and therefore, under a given set of conditions, the use of it enables one to place twice as much carbon in the counter compared with carbon dioxide or methane methods.

Liquid-scintillation counting also provides a possible approach to the problem of measurement, but difficulties in chemical preparation prevent its general adoption.

The actual measurements are complicated by the fact that, in normal circumstances, the background counting-rate of the counter would be very much greater than that due to the sample itself, and steps must be taken to reduce its value. A heavy steel screen with walls 8 in. thick is used to eliminate the effect of local gamma-radiation. The screen at the National Physical Laboratory, which is large enough to accommodate a number of counters, weighs more than 23 tons. The penetrating meson component of

cosmic radiation, against which the steel screen has no effect, is cancelled out by a ring of Geiger counters surrounding the sample counter and connected in anti-coincidence. Other screening precautions which have been shown to be advisable and which are incorporated in the equipment at the Laboratory include a mercury shield, which reduces the background due to traces of radioactivity in the steel screen, and a layer of paraffin wax mixed with boric acid which reduces the component due to neutrons which are in turn induced in the screen by the action of the corpuscular component of cosmic radiation. This neutron flux will also be monitored continuously. Since accurate measurement of these very low disintegration-rates necessarily takes a long time, great emphasis has been placed on the reliable operation of the associated electronic equipment. The instrumentation at the National Physical Laboratory is based on the use, wherever possible, of high-stability circuits as used in computers, and of transistors instead of thermionic valves. The equipment includes a comprehensive system for automatic recording, and a mass spectrometer has also been purchased in order that corrections can be applied for isotopic fractionation effects. The equipment is nearing completion and should be in operation in the near future.

Dr. H. Godwin described how the method is being used in the Cambridge Sub-department of Quaternary Research to give an absolute time-scale to the history of events during the Late Quaternary period, that is, the past 35,000 years or so. The apparatus, designed and built by Dr. E. H. Willis, consists of a proportional gas counter of about 2-litres volume. It is shielded by 7 tons of zinc and lead and an anti-coincidence array of Geiger tubes. It has a net contemporary count-rate of 28 counts per min. and a steady background of 20·7. The equipment was acquired as a result of the generosity of the Nuffield Foundation, but is now maintained by the University of Cambridge.

The oldest sample dated so far was from the Arctic Plant Bed from the Lea Valley. This gives a date of 26,000 B.C. for the time when the mammoth was still alive in Britain. A date from a later horizon in the valley of the Colne, a tributary of the Lea, shows that the full Glacial Period must have persisted until *c.* 11,500 B.C. After the glaciation, there came a period of climatic oscillation, the so-called Allerod Period. The effects of this change can be recognized in deposits at numerous sites throughout the British Isles. Carbon dating on material from such sites shows that there was a temporary mild period between 10,000 and 8,800 B.C., followed by a return of cold for about 500 years. These British dates are in excellent agreement with dates from north-west Europe. As a result, British events are now closely tied up with events at the end of the ice age in Europe.

Following the Allerod oscillation came the climatic improvement of the Post Glacial Period. In the past, pollen analysis has provided a relative time-scale for this period since the characteristic changes in forest composition have permitted the establishment of a sequence of pollen zones applicable, with care, to the whole of the British Isles. A series of twelve datings from a site in Cumberland gives a very consistent series of dates for the successive pollen zones. It remains to be seen how far these pollen boundaries are truly synchronous across the British Isles or Western Europe.

The increased temperature at the end of the last glaciation caused melting of the ice sheets and a rapid rise in ocean-level. One effect of this was the flooding of the North Sea and the isolation of Britain from the European mainland. Dates measured in Cambridge on submerged peat-beds from around the coast of Britain, together with those made at other laboratories, show that a rapid eustatic rise of sea-level was in progress between 12,000 and 4,000 B.C. and that the level rose by more than 200 ft.

In the derelict raised bogs of Somerset, several prehistoric wooden trackways have been recorded and excavated. They appear to have been built in the late Bronze Age at a time when increasing wetness of climate induced flooding of bogs and valleys and caused Bronze Age man to construct these wooden causeways. Radiocarbon dating of seven such structures in Somerset and three others in Lancashire, Cambridgeshire and Lincolnshire show that they were built in the period 500–900 B.C.

The picture which emerged from this discussion is a very hopeful one for the future of radiocarbon dating in Britain. Although the method has certain limitations, the work described by Dr. Godwin illustrates its great value as a tool for establishing an absolute chronological framework to prehistoric events, and the news that Britain's present limited capacity for radiocarbon dating is to be augmented by the considerable resources of the National Physical Laboratory will be welcomed in many quarters. The dates mentioned in the discussion appear in a paper in the *American Journal of Science* Radiocarbon Supplement, Vol. 1 (1959), the new international organ for the publication of radiocarbon dates.

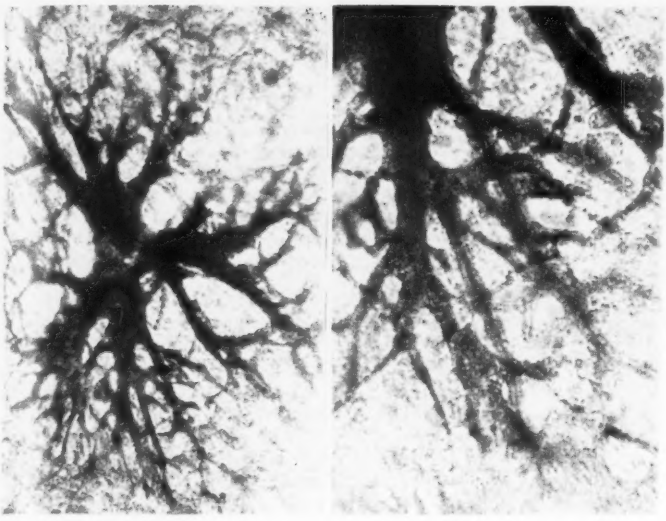
HAROLD BARKER

MECHANISM OF HORMONE ACTION

By Prof. AARON B. LERNER

Section of Dermatology, Department of Medicine, Yale University School of Medicine, New Haven, Conn.

CELLS have specific functions, for example, adrenal cortical cells produce hydrocortisone, nerve cells form noradrenaline, melanocytes make melanin. During their early development cells have in common the capacity to produce substances such as glycogen and protein. The formation of all these end-products depends upon the reaction of specific enzymes with their substrates. Such enzymically catalysed syntheses usually occur in soluble extracts and homogenates which do not contain intact cells. The formation of cellular end-products also is controlled by hormones that require a high degree of cellular organization in order to function. Although the synthesis of a cell's products is regulated by both enzymic and hormonal reactions, these reactions are not related directly to one another. The hormones



a *b*

Fig. 1. The pigment granules in a frog's melanocyte can be dispersed throughout the cell as shown above (*a*, × *c.* 320 ; *b*, × *c.* 720) by keeping the cell in solutions of either low osmotic activity, low *p*H or relatively high potassium and low sodium ion concentration. *α*- and *β*- melanocyte-stimulating hormone and adrenocorticotrophic hormone and caffeine also caused dispersion of granules. While these physical and chemical factors produce the same end effect, namely dispersion of granules within the cell, they do so through different mechanisms (see Figs. 3 and 4). At × 720 magnification the melanin granules are seen easily

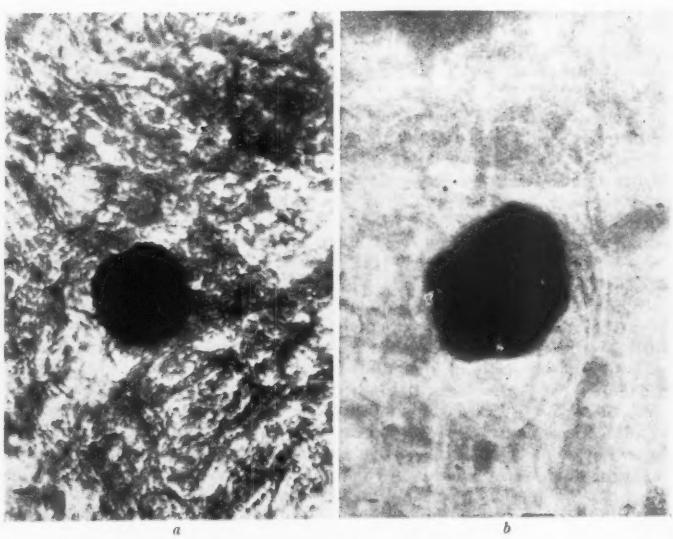
react with the intact cell to initiate a series of reactions, none of which need be enzymic, that result in a re-location of enzymically active particles. Afterwards, the enzymic reactions concerned with the formation of various cell products also are affected. The nature of the first reaction of the hormone with the cell is still unknown. It may involve a specific interaction between the hormone, cytoplasmic structural proteins, ions and water to change the colloidal state of parts of the cell.

In this article I wish to show that the melanin pigment forming cell, the melanocyte, must be intact if hormones are to affect the rate of melanin synthesis. Initially, hormones do not affect the tyrosinase-catalysed conversion of tyrosine to melanin. Instead they produce a change in the location of enzymically active particles which is followed by a change in the rate of enzymic reactions forming melanin. If hormones were added to tissue extracts without intact cells, no effect on melanin synthesis would be observed. A similar mechanism may apply to the action of hormones on cells other than melanocytes.

What makes the melanocyte a unique cell in which to study the action of hormones is that it contains enzymic particles made dark by melanin. Hence, these particles are readily visible. Of course, it cannot be assumed that a hormone like adrenocorticotrophic hormone acts on the melanocyte in the same way as it does on the fibroblast. Nevertheless, the studies with melanocytes are reasonably clear-cut and must be acknowledged. Perhaps at a later date techniques will be made available to facilitate similar observations on other cells.

Melanocytes resemble nerve cells. Embryologically they are derived from the neural crest. The pigment melanin is made in the cytoplasm of the melanocyte by the reaction of tyrosine with oxygen and tyrosinase. Ordinarily this reaction occurs on cytoplasmic particles that contain not only tyrosinase activity but that of other enzymes as well. For example, the tyrosinase particles from mouse melanoma also possess cytochrome oxidase and succinic dehydrogenase activities. The melanin formed is normally attached to these particles—thus the particles are visible. These particles are called melanin granules or pigment granules and are considered to be mitochondrial structures[1].

It is easy to show that some physical and chemical factors induce clumping of melanin granules about the centre of the cell while others cause dispersion of these granules in the cytoplasm away from the centre



a *b*

Fig. 2. The pigment cell above is the same kind as that in Fig. 1 except that the cytoplasmic granules are aggregated about the nucleus instead of dispersed throughout the cell (*a*, × *c.* 320 ; *b*, × *c.* 720). The outer borders of the cell, although not shown in this preparation, are the same as in Fig. 1. Aggregation of granules can be induced by placing the cell in solutions of either high osmotic activity, high *p*H or relatively low potassium and high sodium ion concentration. Melatonin, adrenaline, noradrenaline, acetylcholine, hydrocortisone, serotonin and triiodothyronine also produce aggregation of granules. As in the case of dispersion of pigment granules, aggregation is caused by many factors, all of which produce the same end result but operate through different means (see Figs. 3 and 4)

of the cell. When frog melanocytes are placed in solutions of low osmotic activity or low *p*H, the granules disperse[2]. A similar effect is achieved by changing the cations in the solution from sodium to potassium. A substance like adenosine triphosphate, which may not even enter the cell, also causes dispersion of the granules. Experiments with frog and fish melanocytes indicate that for the dispersion effect to occur the cytoplasm changes from a gel to a sol and oxygen is utilized. One of the most surprising findings associated with this reversible dispersion reaction is that minute quantities of certain hormones can bring it about. The melanocyte-stimulating hormones from hog pituitary gland, α- and β-hormones, produce darkening in concentrations of 1×10^{-11} *M* and 2×10^{-11} *M*, respectively[3,4]. Hog adrenocorticotrophic hormone is effective at 3×10^{-10} *M*. These three peptides have related amino-acid sequences in their structure[5]. Other dispersing agents include progesterone, caffeine, marsilid and mesantoin. However, when compared with α- and β-melanocyte-stimulating hormones and adrenocorticotrophic hormone, huge quantities are required. Melanocyte-stimulating hormone in high concentrations has no effect on the tyrosine-tyrosinase reaction *in vitro*.

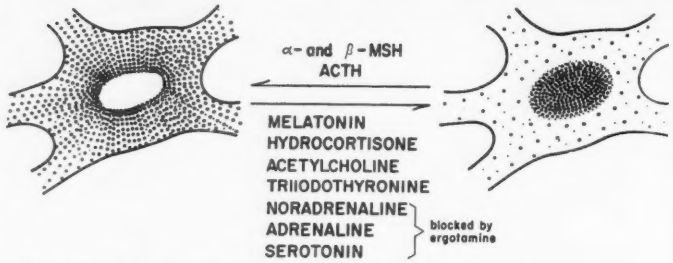


Fig. 3. α- and β-melanocyte-stimulating hormone and adrenocorticotrophic hormone can produce dispersion of pigment granules in the melanocyte. This action can be reversed by the seven compounds listed above. The action of adrenaline, noradrenaline and serotonin but not that of the other aggregating agents can be blocked by ergotamine

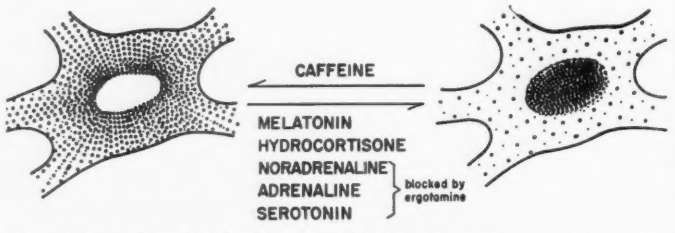


Fig. 4. Caffeine, like α- and β-melanocyte-stimulating hormones and adrenocorticotrophic hormone, causes dispersion of granules in the melanocytes. However, this effect is reversed by melatonin, adrenaline, noradrenaline and serotonin but not by triiodothyronine, acetylcholine or hydrocortisone. The action of adrenaline, noradrenaline and serotonin but not that of melatonin and hydrocortisone can be reversed by ergotamine. Melatonin and hydrocortisone are the only substances known that not only cause aggregation of granules in cells previously darkened by α- and β-melanocyte-stimulating hormone, adrenocorticotrophic hormone or caffeine but also cannot be blocked by ergotamine. However, the action of melatonin and hydrocortisone is not the same. Hydrocortisone acts for only a period of several minutes whereas melatonin has a prolonged action

Aggregation of pigment granules in frog melanocytes occurs in solutions of high osmotic activity or high *p*H. Replacing potassium by sodium ions in the solution results in a similar effect. Results of work on frog and fish indicate that for the aggregation reaction to occur the cytoplasm must change from a sol to a gel. Oxygen is not required. Potent aggregating agents for frog melanocytes include melatonin, noradrenaline, adrenaline, acetylcholine, hydrocortisone, triiodothyronine and serotonin[6,7]. The molar concentrations of these hormones required for the reaction to occur are 5×10^{-12}, 6×10^{-7}, 6×10^{-7}, 4×10^{-7}, 6×10^{-7}, 8×10^{-7} and 3×10^{-6}, respectively[3].

What happens to the melanocyte when the granules are kept in the dispersed or aggregated state? In the case of melanocytes from hamster melanoma, injection of melanocyte-stimulating hormone into the animal results in an increase in melanin content of the tumour whereas injection of melatonin results in a decrease in melanin content[8]. Also, injection of melatonin into frogs results in decreased melanin in the skin[9]. Thus in this case, by dispersing tyrosinase, melanocyte-stimulating hormone can bring about more melanin formation. Melatonin, on the other hand, presumably by aggregating the tyrosinase-containing particles, decreases the formation of melanin. In both cases the effect of the hormones on melanin formation is indirect, operating through their influence on tyrosinase location and activity. The activity of the enzyme could well be related to its location within the cell. As suggested earlier, the direct reaction between a hormone and the melanocyte may involve only a relatively specific reaction between hormone, cytoplasmic structural proteins, ions and water to change the colloidal state of parts of the cell[10]. This change in colloidal state eventually would affect the tyrosine-tyrosinase reaction.

The question arises as to whether or not the effect of hormones on the movement of cytoplasmic particles is peculiar to melanocytes or occurs in other cells as well. In this regard it is of interest that adrenocorticotrophic hormone, cortisone and hydrocortisone affect the structure of mast cells[11]. The latter become vacuolated, diminish in size and acquire irregular outlines. Cytoplasmic granules clump together to form aggregates. Cortisone and hydrocortisone induce the formation of cytoplasmic vacuoles in fibroblasts grown in tissue culture. Hydrocortisone also reduces the amount of collagen formed in cultures of fibroblasts.

What I want to emphasize here is that the experiments with melanocytes 'prove' that the intact cell is necessary for the action of a hormone, when action is used in the sense of controlling the end function for which the cell is known, for example, melanin formation in the case of the melanocyte. To change the rate of melanin formation the hormone exerts an indirect effect on the tyrosine-tyrosinase reaction. It is not possible to demonstrate a direct hormonal effect on this reaction. This situation is somewhat analogous to some of the old problems of mathematics. For years attempts had been made to trisect an angle or square a circle with only a pencil, straight edge and compass, or to find a formula to solve equations of the 5th order. However, in fairly

recent times it has been shown clearly that these problems cannot be solved in a strict sense. Only approximations are possible. In biology, unlike mathematics, clear-cut proofs are hard to come by. But the experiments carried out by many investigators suggest the conclusion that it is essential for the cell or organized cell unit to be intact in order that a hormone may exert its effect.

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THE NUCLEAR-POWERED SHIP, *SAVANNAH*

THE marine world has become accustomed to the reality of nuclear-powered ships through the widely publicized performances of the American submarines *Nautilus* and *Skate* and the building of the Russian icebreaker *Lenin*. These are specialist craft in which the economics, conveniences and safety precautions pertinent to merchant shipping play no part. To test the possibilities of the application of nuclear power to a vessel normally carrying passengers and a mixed cargo the nuclear-powered ship *Savannah*, named after the first steamship to cross the Atlantic, is now being built by the New York Shipbuilding Corporation for the U.S. Atomic Energy Commission and the U.S. Department of Commerce. She is specifically designed as a test ship, to obtain information on practical construction and operating technology, though it is realized that at the present stage the ship is not an economic proposition.

The *Savannah* is of 22,000 tons displacement when loaded, nearly 600 ft. in overall length, and draws 29·5 ft.; she has a cargo capacity of 10,000 tons, carries 60 passengers, a crew of 110, can cruise at 21 knots, and is expected to be ready for unrestricted operation by summer 1960. Externally, the design appears advanced and pleasingly simple. She has sweeping lines with a well-raked stem and cruiser stern. The superstructure incorporating the bridge and sheltered decks is placed well aft, with four holds forward of the bridge. Passenger accommodation is conventionally luxurious, while cargo-handling equipment is of the most advanced and fastest type.

The propulsion plant normally develops 20,000 s.h.p. absorbed by a single screw. The pressurized water reactor, the type used in the *Nautilus*, is fuelled by uranium oxide with about 4·4 per cent enrichment of uranium-235, clad in stainless steel rods, and cooled by light water at a pressure of 1,750 lb./sq. in., heat being abstracted from the core by a three-pass flow arrangement. Emphasis has been placed on the necessity for a long lifetime of the core, the design target being 52,000 MW. days or 3½ yr. under normal operating conditions; a large low-density core is therefore used, while the use of uranium-235 as a fertile material is expected to extend the life of the core through its conversion to plutonium. The variation of power output demanded from the bridge can be met by automatic operation of the boron – stainless steel control-rods.

At normal load the inlet temperature of the primary coolant, demineralized water flowing through two closed loops, is 494·7° F. and the outlet temperature 521·3° F., the coolant being circulated by four pumps and the heat supplied by the reactor rejected to the secondary circuit steam generators. The primary water is continually purified to remove corrosion, fuel and fission products.

The heat rejected by the primary coolant is used to generate steam in the secondary circuit from two generators which supply dry saturated steam at 490 lb./sq. in. to high- and low-pressure De Laval turbines driving the main shaft through a double reduction gear. Two 1,500-kW. steam-turbine generators provide power for auxiliary services and a low-pressure heat exchanger provides steam for hotel services and space heating. For emergency two 750-kW. diesel-driven generators provide power for removal of reactor heat after shut-down and will supply essential services, including the take-home motor coupled to the main shaft.

The installation of nuclear power plants in merchant shipping presents grave problems of ensuring the complete safety not only of both passengers and crew, but also of the inhabitants of the ports of call. It is not sufficient to guard against the hazard of a major explosion. Complete precautions must also be taken against the possibility of irradiation caused by collision or by the sinking of the ship in shallow water. Safety considerations have been elaborate on the *Savannah*. The design of the hull is such that the ship will remain afloat with two of the eleven main compartments flooded: this is not an abnormal requirement, but in the *Savannah* elaborate collision bulkheads and collision mats ensure that a ramming ship would have to penetrate 17 ft. of stiffened ship structure before the containing vessel of the reactor was affected. The inner bottom below the reactor is also strengthened by transverse and longitudinal members to form an 'egg crate' construction. It is estimated that the reactor compartment is impervious to any collision with all but 1 per cent of the world's mercantile marine; the likelihood of high-speed collision in harbour waters is considered negligible.

The chief radiation sources are the reactor core and the primary coolant. The reactor is shielded by a lead-covered steel tank which surrounds the reactor with an annular water space. It is estimated that the dose-rate outside the primary shielding will not exceed 200 mr. per hr. 30 min. after shut down. This rate is low enough to permit approach for inspection and maintenance. The whole of the primary system is further surrounded by a containing vessel, designed to limit the radiation in the holds to 5 r. a year and to 0·5 r. a year in the passenger spaces. The containing vessel, cylindrical in shape, 35 ft. in diameter by 50·5 ft. long, also serves to

prevent spread of radioactivity in the event of any rupture of the primary system. The lower half of this vessel is of concrete surrounded by water tanks, while the upper half is of lead slabs surrounded by polyethylene. Should the ship sink in deep water, two of the manholes will open automatically to equalize pressure and then close to prevent undue leakage of radiation products. Provision is also made in the case of shallow-water sinking to allow purging of the containing vessel or filling it with concrete. The total weight of the containing vessel is about 2,000 tons.

Waste liquids likely to be radioactive are fed to storage tanks and will not be discharged at sea except under the conditions set forth by the Maritime Administration and the Atomic Energy Commission. Radioactive gases are diluted and discharged up the radio mast after being filtered. Purging of the air of the containing vessel, of which the argon is slightly radioactive, is carried out periodically at sea. Cooling of such components as primary circulating pumps is effected by fresh water cooled by sea water in an intermediate circuit. The sea water does not become radioactive.

Apart from the care taken in the design and construction of the ship, extensive training in nuclear reactor theory and its marine application is being undertaken by the candidates for the posts in the *Savannah*. The longest course taken by engineering-officer candidates occupies fifteen months. A shorter course has also been arranged and is intended for candidates already possessing a science degree and includes seven observers from Britain, Denmark, Holland and Japan.

F. D. Robinson

OBITUARY

Sir Alfred Egerton, F.R.S.

Alfred Charles Glyn Egerton died suddenly on September 7 following a heart attack. He was on holiday at the time at his house at Mouans Sartoux in the south of France, with his wife and son Francis. He was seventy-two, but was in full vigour; his sudden death comes as a great blow to all those in combustion science, in which Sir Alfred has been the acknowledged leader for many years. He had also made many important contributions in engineering, and in scientific administration and education.

He was educated at Eton, where he took the science prize and founded the College Scientific Society, and at University College, London, where he gained first-class honours in chemistry and was later president of the College Chemical and Physical Society. He studied at Nancy and in Berlin with Prof. W. Nernst, and in Sir William Ramsay's private laboratory as his last research student. During 1909–13, he was instructor at the Royal Military College and, during the First World War, carried out research on explosives and had his first contact with chemical engineering.

After the War Egerton went to the Clarendon Laboratory at Oxford and carried out researches on the vapour pressures of metals at high temperatures and, in advance of his time, worked on the separation of zinc isotopes. He was appointed reader in thermodynamics in 1923. During a British Association meeting in Canada, Sir Harry Ricardo and Sir Henry Tizard, with whom his friendship was life-long, aroused his interest in combustion and in the role of the newly discovered 'anti-knocks'. He applied his knowledge of physical chemistry to this problem of knock in internal combustion engines and put forward the view that break-down of unstable organic peroxides was responsible for 'pre-sensitizing' the premature detonation. His interest in combustion continued throughout his life, and he and his research group published a steady stream of valuable papers on the role of peroxides in combustion, on peroxide analysis, on slow combustion processes, on gaseous detonation, on limits of inflammability, on burning velocities, and on techniques for these studies, such as the use of absorption spectra and the development of the flat-flame burner.

Egerton also carried out or stimulated work in many fields of applied science. He made measurements of the properties of that important working substance steam, and stressed the value of methane or natural gas as potentially the most efficient fuel for the internal combustion engine, and worked on the combustion, liquefaction and bulk handling of methane. This led to an interest in liquefaction problems, and he was active in founding the Low Temperature Group of the Physical Society, of which he was first chairman in 1946.

He was elected to the Royal Society in 1926, and in 1936 was appointed professor of chemical technology in the Imperial College of Science and Technology (University of London), a position which he held until his retirement in 1952. During his tenure of the chair, he started the undergraduate course in chemical engineering and pioneered the development of this subject in Great Britain. The Department, under his guidance, became a leading centre in both combustion research and chemical engineering.

Egerton was secretary (physical sciences) of the Royal Society during 1938–48, during the important War period, and he was also a member of the Scientific Advisory Committee of the War Cabinet during 1940–45. In 1942, he spent some time in Washington in charge of the British Commonwealth Scientific Office, where he did important work improving Anglo-American co-operation. His membership of numerous committees gave him a tremendous breadth of knowledge of affairs and of people. At various times he was chairman of the following committees: the Heating and Ventilating Committee; the Fuels and Propulsion Committee, Admiralty Scientific Research Department; the Scientific Advisory Council, Ministry of Fuel and Power; the committees reporting to the Government of India on the Indian Institute of Science, and on the sixteen Government of India laboratories; the Scientific Advisory Committee of the British Council; the Combustion and Fuels Committee of the Aeronautical Research Council; and the Royal Society Scientific Information Conference. He had been director of the Salters' Institute of Industrial Chemistry and a manager of the Royal Institution. He was president of the British Section of the Combustion

Institute, editor of *Combustion and Flame*, and formerly of *Fuel*. He was active in work on the dissemination of scientific information (*Science Abstracts* Committee), on the use of scientific man-power (Barlow Committee) and on the use of the world's fuel and energy resources. His educational interests are shown by his active membership of the governing bodies of Winchester College and of Charterhouse. Last year, he was responsible for the successful organization of the seventh International Combustion Symposium in Oxford. His recent intense activity had been on the Government Committee of Inquiry into the Fishing Industry, and in research into the characteristics of smouldering for the Tobacco Manufacturers' Standing Committee. His work was recognized by a knighthood in 1943 and a number of honorary degrees and medals, including the Rumford Medal of the Royal Society in 1946.

In 1912, he married the Hon. Ruth Cripps, only daughter of the first Baron Parmoor, sister of his close friend at University College, the late Sir Stafford Cripps.

As a man, we remember his quiet unassuming manner, his unfailing smile of greeting, his tireless work on his many scientific interests, and his delight in his second career as a painter. Somehow, despite his many activities, he always had time to spare for everyone. He had the genius for bringing out the best in those with whom he worked and took a fatherly interest in the numerous research students he sponsored, so many of them now in high positions in science and industry. This keen personal interest in his students, colleagues, and indeed in all he did, was fully shared by Lady Egerton. His life and work are an example to all those whom he has influenced.

A. G. Gaydon

NEWS and VIEWS

Biochemistry at Birmingham : Dr. S. V. Perry

The development of a Department of Biochemistry in the University of Birmingham, arising as it does in part from the former Department of Industrial Fermentation, needs for guidance a man of scientific ability and vigorous powers of leadership. The appointment of Dr. S. V. Perry to be professor of biochemistry has recently been announced. Dr. Perry graduated with first-class honours in biochemistry in the University of Liverpool in 1939 and was elected to the Isaac Roberts research scholarship upon graduation. After the Second World War he was elected a Rouse Ball research student of Trinity College, Cambridge, and began his researches on muscle biochemistry in the Department of Biochemistry. He was elected a research fellow of Trinity College, Cambridge, in 1947 and a Commonwealth Fund Travelling Fellow in 1948, spending the year 1948–49 in the Department of Physiology of the Medical School of the University of Rochester, New York, investigating the biochemical properties of skeletal muscle. In 1950 he was appointed a lecturer in biochemistry in the University of Cambridge. His researches have been largely concerned with biochemical function in relation to intracellular morphology with particular reference to the muscle cell. A study of the intracellular components of striated muscle has been pursued in an investigation of the biochemistry of the cell in general, and of the contractile process in particular. These studies are throwing important light on the nature of the association between muscle proteins and the role of their interaction in muscular contraction. Dr. Perry has taken part, by invitation, in a number of international congresses concerned with the biochemistry of muscle, and has published many articles on this subject in the *Biochemical Journal* and other scientific periodicals.

Analytical Chemistry at Birmingham : Prof. Ronald Belcher

The award of the title of professor of analytical chemistry is a tribute to the work Dr. Belcher has done at Birmingham in building up the School of Analytical Chemistry, which is unique in Great Britain. The honour comes at an appropriate time, since he is at present the president of the Analytical Chemistry Section of the International Union of Chemistry and a vice-president of the Union. Prof. Belcher received his early education in Sheffield and gained his first qualifications through the Royal Institute of Chemistry. After carrying out extensive researches since 1928 on coal at the University of Sheffield, he became a lecturer in chemistry in the University of Aberdeen in 1946, moving to Birmingham in 1948. Since that time a constant flow of papers has come from his group and no less than twenty-eight higher degrees have been awarded to graduates in analytical chemistry under his supervision. With pupils and colleagues he has published more than 150 papers and ten well-known books, all in the field of analytical chemistry, and to these and his many editorial and committee activities he owes his world-wide reputation. He gained the Ph.D. and D.Sc. of the University of Birmingham. With the vast extensions of the Chemistry Department at Birmingham nearing completion, Prof. Belcher and his colleagues will have greatly increased facilities for research and the training of analysts at all levels.

Mathematical Physics at Birmingham : Prof. G. E. Brown

The title of professor of mathematical physics has been conferred on Dr. G. E. Brown, at present reader in the Department of Mathematical Physics. Dr. Brown, who is a citizen of the United States, studied in South Dakota State College, at the Universities of Iowa and Wisconsin, and after war service became a graduate student at Yale in 1947 and obtained his Ph.D. there in 1950. He was awarded the D.Sc. of the University of Birmingham in 1957. He went to Birmingham with a post-doctoral award in 1950, was appointed a research fellow in September 1950 and has been on the teaching staff since 1954, except for a period of study leave from January to September 1958, which was spent in the Institute for Theoretical Physics in Copenhagen. He has published numerous papers on different aspects of quantum theory, particularly on relativistic electron theory, including relativistic corrections in atomic problems. More recently he has done important work in nuclear theory, including a series of papers with various collaborators on the relation between the nuclear many-body problem and the 'optical model'.

National Science Foundation : Dr. David D. Keck

The National Science Foundation has announced that Dr. David D. Keck has resigned his position at the New York Botanical Garden in order to remain permanently as programme director for systematic biology at the Foundation's Division of Biological and Medical Sciences. The Systematic Biology Programme receives research proposals and administers more than three hundred active grants. In 1950, Dr. Keck joined the staff of the New York Botanical Garden as head curator ; he became assistant director in 1955 and served as acting director in 1958. From 1926 until 1950 he was on the staff of the Division of Plant Biology of the Carnegie Institution of Washington, at Stanford, California. There he was a member of a research team concerned with pioneer work on the nature of plant species. He is the author of many technical papers and has collaborated with Philip A. Munz in writing "A California Flora" that has just come from the University of California Press.

Microbiological Research

In a written answer in the House of Commons on July 21, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, stated that since the Council for Scientific and Industrial Research announced last December its intention to encourage university research in microbiology, ten applications had been received for grants for research projects in microbiology not previously supported by the Department of Scientific and Industrial Research and all these applications had been approved.

Zenith Reactor

A question was asked in the House of Lords on July 15 about the 'Zenith' low-power reactor installed at Winfrith Heath mainly to further the work of the European Nuclear Energy Authority project for research on a high-temperature gas-cooled reactor. In reply, the Minister of Power, Lord Mills, said that the project would pay rent to the Atomic Energy Authority for the use of the reactor. It was hoped that about half the professional staff would be provided from signatory countries other than the United Kingdom. Of the total estimated cost of the project, £10 million would be contributed by the participants, the United Kingdom supplying the balance of £3·6 million and would retain ownership of the reactor and other equipment in Britain when the project was terminated. The work would be carried out by the Atomic Energy Authority, but all participating countries had their say on various matters connected with the project.

Chief Inspector of Nuclear Installations

In the course of the debate in the House of Commons on July 2, when the Nuclear Installations (Licensing and Insurance) Bill was given its third reading, it was stated that the Minister of Power intended to appoint a chief inspector of nuclear installations who would be responsible for advising on the measures to be taken to carry out the Minister's responsibilities under the Act. The appointment had been offered (pending the Royal Assent) to Major-General S. W. Joslin, who had accepted it. Major-General Stanley William Joslin was educated at Hackney Downs School, Royal Military Academy, Woolwich, and the University of Cambridge. He held the appointment of director of mechanical engineering at the War Office, until he joined the United Kingdom Atomic Energy Authority in 1954, and later became deputy director (personnel) of the Industrial Group. As chief inspector, Major-General Joslin will be the head of the inspectorate, and one of his main tasks will be to advise on the organization and build-up of the inspectorate.

Exchanges between Soviet and U.S. Scientists

The U.S. National Academy of Sciences and the U.S.S.R. Academy of Sciences have announced the signing of a two-year agreement providing for exchange visits by research scientists of each country for periods up to one year. Under the terms of the agreement, each Academy named twenty fields of specialized scientific inquiry in which its scientists wish to observe or conduct research within the host country. In addition, the agreement provides that the two Academies will organize joint symposia dealing with scientific problems of current interest, assist each other in the exchange of scientific information, and on a reciprocal basis exchange invitations to important scientific meetings. Implementation of these provisions will substantially increase the exchange of scientists between the two countries.

Colonial Development

The annual report of the Colonial Development Corporation for 1958 (London : H.M. Stationery Office. Pp. v+69. 4*s*. 6*d*. net) and the last over the signature of Lord Reith, who was succeeded as chairman on March 31 by Sir Nutcombe Hume, records 77 continuing projects compared with 76 the previous year. Four have stopped, and of the five new projects approved, one, Federation Chemicals, Ltd. (Trinidad), for the first time associates Corporation money with American technique and finance in a Colonial territory. Much effort has been spent in Nigeria in seeking to bring about joint development companies in partnership with regional Governments, and it is understood that the Corporation's view that such companies have a particular importance as instruments through which Nigerians and the Corporation can share responsibility in investigating and launching development projects will be accepted. Capital approved for new projects and for expansion and completion of existing ones amounted to £3 million compared with £6 million in 1957, and gross new expenditure was £6 million. The report claims that the work of the Corporation has increased Colonial production of rice, citrus, pineapples, bananas, palm oil, cocoa, coffee, tea, margarine, flour, meat and fish, and also of gold, silver, copper, timber, cement, manila, hemp, wattle extract, rubber, hides, tobacco, tung oil, copra, electricity, houses, factories, roads and bridges. Besides assisting in the creation of such productive assets as hydroelectric installations in Dominica, St. Vincent, Rhodesia and Kenya, irrigation canals in Swaziland, roads and bridges in Ghana and Nigeria, and in making more than 500,000 acres of idle land productive, direct projects of the Corporation provided employment for more than 16,000 workers.

Lord Reith claims, however, that much more could have been done, and while he stresses the need for first-class management and for trusting the Corporation to use its commercial judgment in the best interests of overseas development and thus of Great Britain itself, he is strongly critical of its relations

with the Government and of consequent frustration and discouragement possibly due to differences of interpretation of the Overseas Resources Development Act. Lord Reith suggests that a rapid review of the working of that Act might be helpful. He complains particularly of the extent to which applications for projects are held up, apparently through disagreement as to the nature of the work the Corporation should do and the degree of control which the Government should exercise over it. He points out that the restrictions imposed upon the future activities of the Corporation in the emergent territories will deny them the full use of its unique facilities and managerial experience at the critical transitional stage of their development, in spite of the obligation for ensuring continuing development finance in such territories which the Government appeared to recognize at the Montreal Conference.

Chinese Scientific Literature

THE Lending Library Unit of the Department of Scientific and Industrial Research is now issuing a list of current periodicals received from China. The first list (July 1959) gives the titles of one hundred periodicals which are being received regularly, and these publications can be borrowed from the Unit by approved borrowers of the Science Museum Library, provided Science Museum Library loan requisition forms are used. Twenty-one of the periodicals listed are obtained by exchange, and special attention is directed to *Scientia Sinica* (in English) and to *Science Record* (in English, French, German and Russian). The periodicals listed are annotated according to the category of readers for whom they are intended, and whether they include contents lists or abstracts in a Western European language. This first issue also includes a note on the Chinese phonetic alphabet.

Mordell's "Reflections"

CAMBRIDGE mathematicians have sometimes mitigated the austerity of their scholarship on retirement, and to this wise relaxation we owe Hardy's "Apology", Littlewood's "Miscellany" and now Mordell's "Reflections" ("Reflections of a Mathematician", by Prof. L. J. Mordell. Pp. vii+50. Montreal: Canadian Mathematical Congress, Chemistry Building, McGill University or École Polytechnique, 2500 Guyard Avenue. 1959. n.p.). In this collection of short, informal essays, the author is primarily interested in explaining the point of view of the professional mathematician to fellow scholars who are not mathematicians. He is not concerned with applications, but with mathematics itself—what it is, the fascination of its aesthetics and its techniques, the difficulties and triumphs of creative work, not without some mild insinuation that the theory of numbers is the crown of mathematics. Two of his points deserve emphasis. The first is that the three cardinal virtues for the young mathematician are faith, hope and curiosity, and that the greatest of these is curiosity. Secondly, he stresses that the mathematician's task is not ended when he has solved his problem; he is under an obligation to his fellow-workers to present his results clearly and intelligibly, and must not allow the economic demand for brevity to result in obscurity. The selection of precisely the right number of steps required to support the argument, so that it shall be neither tedious nor obscure, is a matter to which the young mathematician should pay careful attention. Mordell in this connexion quotes with approval Polya's advice: "if you have two things to say, say them one at a time".

Museum of Applied Arts and Sciences, Sydney

THE Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney, for 1957 (Pp. 20. Sydney: Museum of Applied Arts and Sciences, 1959) stresses the great urgency of allocating a site for a new museum. It points out that a modern science museum requires an extensive area and building, not only to preserve and display its national treasures in an appropriate manner, but also to exhibit full-sized engineering exhibits. Within the limits of the resources of the Museum, provision was made to show the advance of science during the International Geophysical Year. Also by means of films, diagrams and models visitors were presented with the development of guided missiles and space satellites. The results of research by the staff in the field of essential oil are drawing increasing numbers of inquiries from all over the world. Since the Museum deals principally with applied science, it was always necessary to strike a balance between pure and applied research by the staff.

Further Botanical Collections

THE great tradition of travelling and collecting plants, which, among others, we associate particularly with the name of Linnaeus and his followers and adherents, is still very much alive in Sweden. A recent issue of the *Arkiv för Botanik* (4, Part 1; 1959; Kungl. Svenska Vetenskaps—Akademien, Stockholm) is of special interest in this connexion in that it contains many new floristic records based on expeditions to places of such unique interest as the Juan Fernandez Islands. Several of the contributions, on Hepaticæ (S. Arnell), Mosses (E. B. Bartram), Uredinales (I. Jørstad), relate to materials chiefly collected in the course of an expedition by the eminent Swedish botanist, Dr. C. Skottsberg, and his wife during 1954–55 to these islands. Some of the records also relate to the Falkland Islands and South America. There is also an account of Annonaceae by von Rob. E. Fries, based on specimens collected by Dr. Eric Asplund during his travels in Ecuador in 1955.

The Ciba Foundation, 1949–59

THE Ciba Foundation, founded in 1947 by the Swiss firm, Ciba, Ltd., of Basle, for the promotion of international co-operation in medical and chemical research, shows in its report for the years 1949–59 a remarkable record of success. Housed at 41 Portland Place, London, W.1, in a building designed by the brothers Adam which was built in 1778, and is now scheduled as a building of historical and architectural interest, the Foundation, through its Trustees, Executive Council and International Scientific Advisory Panel, has arranged numerous international conferences, colloquia and discussion meetings on various subjects, as well as the Ciba Foundation annual lectures and scientific-film sessions (The Ciba Foundation for the Promotion of International Co-operation in Medical and Chemical Research. Ten Years Report for 1949–1959. Pp. 1–64. The Ciba Foundation, 41 Portland Place, London, W.1). A feature of the colloquia and conferences is that they are attended for three or four days by experts in various fields of work from various countries who are invited to take part, the number attending being kept low, great importance being attached to free discussion and social contacts

between the participants. Other activities of the Foundation are the one-day Study Groups, which are held in honour of overseas members of the Foundation's international scientific advisory panel and similar one-day meetings, or 'Research Fora', which are held on behalf of sponsoring individual or scientific societies. The Foundation also provides accommodation and hospitality for various scientific organizations. Its Library includes autographed copies of works by distinguished scientific men and tape-recordings of the Foundation's meetings. The Foundation, in co-operation with the Institut National d'Hygiène, Paris, offers twelve Anglo-French Medical Exchange Bursaries of £50 a month tax-free for two to four months for the study of special techniques in Great Britain and France. A glance through the list given in this report of the subjects discussed at the Foundation's various meetings shows that, although the emphasis has been on endocrinology and problems of ageing, these discussions have dealt with many of the most important lines of modern medical research. Results have been published in some forty-seven volumes issued by Messrs. J. and A. Churchill, London.

Oreopithecus

Since the discovery in 1872 of the lower jaw of the fossil primate *Oreopithecus* in lignite deposits in Italy, conflicting views have been expressed by various authorities on its taxonomic status, but in general there has been in the past a consensus of opinion that it represents an aberrant type of cercopithecoid monkey, showing in its dentition some approximation to the anthropoid apes. The discovery in recent years by Dr. J. Hürzeler, of the Basle Museum, of many more specimens of this Lower Pliocene primate, including the skull and much of the post-cranial skeleton, has lent some support to the contention that it is more closely related to the anthropoid apes. But Dr. Hürzeler goes further than this, and has argued that the dentition and skeleton show some hominid features which suggest that *Oreopithecus* is properly to be regarded as a Pliocene representative of the very base of the hominid stem. In a careful study of a maxilla with the upper dentition in the British Museum by P. M. Butler and J. R. E. Mills (Bulletin of the British Museum (Natural History). Geology. Vol. 4, No. 1 : A Contribution to the Odontology of *Oreopithecus*. Pp. 1–26 + plate 1. London : British Museum (Natural History), 1959. 10*s*.), the authors adduce strong reasons for affinities with the anthropoid ape family but find no good evidence for a hominid relationship. They regard such 'hominid' features of the dentition as have been described as probably the result of parallel evolution associated with the abbreviation of the facial skeleton and a reduction in size of the canine teeth. They conclude that *Oreopithecus* should be retained in a separate family, Oreopithecidae, as originally maintained by Schwalbe (1916), and that it is probably a representative of a phyletic line which developed independently of the evolution of the modern anthropoid apes or the Hominidae. The material collected by Dr. Hürzeler still more recently may perhaps lead to a modification of this point of view, for according to an article which appeared in *Antiquity* (33, 131 ; 1959) it is stated "on information received"—but not yet published—that the post-cranial skeleton shows some clearly marked anthropoid ape features combined with a few which could be regarded as hominid characters. But a final decision on the status of *Oreopithecus* will no doubt depend on how far it is possible to make correction for the distortion by crushing which has evidently affected much of the fossil material.

Floral Abnormalities in Broccoli

D. R. Sampson and M. MacArthur have described some interesting floral abnormalities which apparently arise spontaneously in green sprouting broccoli (*Annals of Botany*, N.S., 23, 211; 1959). Of the several types of abnormalities that may develop in a raceme, flowers with united sepals bearing ovules ventrally on placentae along the lines of sepal union, and pads of stigmatic tissue at the apices of the sepals, are among the most conspicuous. Other curious developments include open, boat-shaped gynœcia, and irregular terminal structures suggestive of laterally united gynœcia. Developmental aspects are discussed and some of their morphogenetic implications noted.

Nitrate Reductase from Germinating Wheat Embryos

The isolation and purification of a soluble enzyme, a nitrate reductase, from embryos of germinating wheat have been described by D. Spencer (*Australian J. Biol. Sci.*, 12, 2, 181; 1959). This enzyme is coupled specifically to reduced diphosphopyridine nucleotide. Addition of flavin adenine dinucleotide to the purified enzyme results in a threefold increase in activity. Flavin mononucleotide is without effect. Potassium cyanide and sodium azide cause 50 per cent inhibition of enzyme activity at $1{\cdot}6 \times 10^{-6} M$ and $2 \times 10^{-5} M$ respectively. The effect of a range of other inhibitors is reported. The presence of inorganic phosphate is required for maximum activity. The dissociation constant (K_s) of the nitrate–enzyme complex is $3{\cdot}8 \times 10^{-4}$ M, and that of the diphosphopyridine nucleotide–enzyme complex is 8×10^{-6} M. The *p*H optimum for enzymatic activity is 7·4.

Climatic Changes and Secular Solar Activity

The Geophysical Institute of the Czechoslovakian Academy of Sciences has published a paper by Z. Gregor and L. Křivský on the long-duration changes in the climate of the Atlantic-European area as related to the secular solar activity (*Geophysical Sbornik*, No. 62 : 1957. Russian texts. Czech and German summaries). These climatic changes, expressed by the circulation of the atmosphere and the movement of the frontal zone, lead to an increase of the average temperature in this area, and promote the recession of glaciers. The changes are attributed to the secular changes in the emission of solar energy.

Infra-red Absorption Bands

The measurement of the intensity of infra-red absorption bands is important both in theory for the deduction of bond moments and hence structural studies, and in practice because it is the basis of quantitative analysis by infra-red methods. Until about 1946 the subject was comparatively neglected because of the scarcity of reliable instruments, but since then a considerable literature on the subject has been built up and the bibliography compiled by R. G. Gillis (*Australian Defence Standards Laboratories Technical Memorandum* 2 : The Intensity of Infra-red Absorption Bands : a Bibliography. Compiled by

Dr. R. G. Gillis. Pp. i + 48. Maribyrnong, Victoria: Defence Standards Laboratories, Department of Supply, 1958), covering work up to the end of 1957, should be most valuable. 134 references on the theory and application of intensity measurements contained in *Chemical Abstracts* are collected together with their abstracts. They are arranged substantially in chronological order within the thirteen sections entitled: early work (pre-1946); general (theory); general (experimental); simple molecules; C—H and C—D bands; hydrocarbon analysis; O—H and O—D bands; N—H and N—D bands; ester and ketone C = O bands; steroids; C ≡ N bands; pressure broadening; and pressure-induced absorption. Since the principles of quantitative analysis are now well known, references to many methods for the quantitative determination of particular compounds have been specifically omitted from the bibliography.

*p*H Measurements

Analytical Measurements, Ltd., Richmond, Surrey, is supplying an analytical pocket *p*H meter which can be used to make *p*H measurements with small amounts of solution. It is complete with batteries and a case of plastic tubes of buffer solution. The meter has a scale from 0 to 14 *p*H and an accuracy of 0·1 *p*H is obtainable. The assembly is in a waterproof case; the electrometer tube, switch and input connector are sealed in a single unit and the weight with accessories is only 3 lb. The current price is £39 18*s*.

Shell Chemical Co. Reorganization

Certain of the operations of the Shell Chemical Co., Ltd., are to be integrated into three divisions corresponding to the three main fields in which it is engaged, namely, industrial chemicals, agriculture and plastics. These changes became effective on July 1. The manager of the Industrial Chemicals Division is Mr. P. J. March. This Division deals with solvents, general chemicals, resins and detergent products. The existing agricultural organization remains unchanged as the Agricultural Division under Mr. H. G. Huckle. The Plastics Division has assumed responsibility for polyolefins, polystyrene, polyvinyl chloride and synthetic rubber. The manager of this Division is Mr. V. N. Luke.

Rare Earth Metals

Successful production of all the rare earth metals has been achieved by Johnson, Matthey and Co., Ltd., following some active research over the past few years. Supplies of the rare earths in their normal form as oxides have been available in several grades of purity; however, improved techniques for the production of the metallic elements have now been brought to fruition, and all the fourteen naturally occurring elements, together with the closely related elements scandium and yttrium, are now available in a variety of forms. The metals are reduced from their fluorides with lithium, calcium or lanthanum in tantalum crucibles in an atmosphere of argon, and are then re-melted in vacuum. Impurities are held at a very low level and in some cases the purity is higher than has hitherto been achieved.

Society for Applied Bacteriology

At the annual meeting of the Society for Applied Bacteriology, held in London on July 8, the following were confirmed in office: *Hon. President*, Mr. D. A. McKenzie; *Hon. Treasurer*, Mr. G. Elis Jones; *Hon. Editors*, Dr. S. E. Jacobs and Dr. C. A. E. Briggs; *Hon. Publications Manager*, Mr. A. H. Walters; *Hon. Advertising Manager*, Mr. E. J. Mann; *Members of Committee*, Dr. Eve Billing, Mr. N. J. Butler, Prof. E. L. Crossley, Dr. J. G. Davis, Mr. B. M. Gibbs, Mr. D. J. Jayne-Williams, Dr. Jane Meiklejohn, Dr. G. C. Ware and Dr. M. Woodbine. After eight years as hon. secretary of the Society, Mr. G. Sykes announced his resignation. His place will be taken by Dr. Ella M. Barnes, Low Temperature Research Station, Downing Street, Cambridge. This change will take place towards the end of October.

Josiah Macy, Jr., Foundation Grants

Unrestricted grants amounting to 1,650,000 dollars to eleven private medical schools in support of their teaching research staff have been announced by the Josiah Macy, Jr. Foundation, New York. The Foundation has made unrestricted grants of 50,000 dollars per annum for a three-year period to each of eleven private medical schools for strengthening their research teaching staff, particularly in the medical science departments.

National Science Foundation Grants

The National Science Foundation of the United States has announced the award of fourteen grants totalling 1,534,500 dollars. The aim is to strengthen biological research by helping to provide scientists with new or modernized facilities and specialized experimental equipment. Major grants are to be awarded as follows: 250,000 dollars to the Woods Hole Oceanographic Institute, Massachusetts; 171,600 dollars to the Bernice P. Bishop Museum, Hawaii; 162,000 dollars to the Marine Laboratory, University of Miami; 155,000 dollars to the California Institute of Technology; 150,000 dollars to the University of Chicago; 135,000 dollars to the Long Island Biological Association; and 105,000 dollars to the Woods Hole Marine Biological Laboratory. Other recipients are: White Mountain Research Station, University of California; California Academy of Sciences; Colorado State University; University of Chicago; University of Missouri; Marine Laboratory, Duke University, North Carolina; and the Academy of Natural Sciences of Philadelphia.

The Alvarenga Prize

On July 14 the College of Physicians of Philadelphia awarded the Alvarenga Prize for 1959 to Dr. Hilary Koprowski, professor of research medicine, University of Pennsylvania, for his outstanding work on the development of a living attenuated virus vaccine against poliomyelitis. The Alvarenga Prize was established by the will of Pedro Francisco DaCosta Alvarenga, of Lisbon, Portugal, an associate fellow of the College of Physicians of Philadelphia, to be awarded annually by the College of Physicians on the anniversary of the death of the testator, July 14, 1883.

Carlsberg-Wellcome Travelling Research Fellowships

The Carlsberg Foundation (Copenhagen) and the Wellcome Trust (London) announce a third series of awards of these Fellowships, which they jointly instituted in 1957. The successful candidates for 1959–60 are Mr. Michael Weis Bentzon, head of the Statistical Department of the State Serum Institute, Copenhagen, and Mr. John Anthony Hunt, at present

working in the Medical Research Council's Research Unit for Molecular Biology at the Cavendish Laboratory, Cambridge. Mr. Bentzon will work with Prof. M. S. Bartlett in the University of Manchester on the application of modern statistical theory of biological problems and Mr. Hunt will study methods of protein chemistry with Prof. M. Ottesen at the Carlsberg Laboratory, Copenhagen.

Lalor Grants and Awards for 1960

The Lalor Foundation has announced the programme of awards for 1960 which it is offering for research in the biological sciences. These awards are to be for support of research on the fundamental biochemical and physiological mechanisms concerned with fertility and reproduction in various forms of life. The objectives are to further the knowledge and understanding of the basic phenomena involved and to extend and develop the possibilities for effective regulation and control. The awards may range up to 8,000 dollars a year, depending upon the scope and duration of the projects approved. Preference will be given to younger members of university and college staffs with an upper age limit of 45 years. The work may be carried out at the applicant's own institution or elsewhere. The Foundation will also grant postdoctorate summer or short-term research awards at the Marine Biological Laboratory at Woods Hole, Mass., or elsewhere for appropriate projects in the fields specified. For these awards, the stipends will normally not exceed 900 dollars for a single man or a woman, 1,100 dollars for a married man working at his home institution, and 1,250 dollars for a married man with principal programme at another institution. Application and inquiries should be sent to the Lalor Foundation, 4400 Lancaster Pike, Wilmington 5, Delaware, and applications must be received by January 15, 1960.

Selby Fellowship

It is announced that Messrs. H. B. Selby Pty., Ltd., of Australia, have placed at the disposal of the Australian Academy of Science the means to establish a research fellowship, to be known as the Selby Fellowship. The intention of the gift is to recognize that, whereas there are numerous scholarships that enable Australian graduates to proceed overseas for research experience, there is now a need for measures to bring young graduates from British and other overseas universities for postdoctoral work in Australian laboratories. The Selby Fellowship is intended as a contribution to this problem. The Fellowship may be awarded for work in any branch of physical or biological science, and is tenable at any university or research institution in Australia by applicants less than thirty years of age. In general, applicants should hold the Ph.D. degree or have equivalent status and experience, but the Fellowship will not normally be given to those who have already held a senior research award. The Selby Fellowship will normally be tenable for one full year of work in Australia. This year applications will close on November 1 with the Assistant Secretary, Australian Academy of Science, Gordon Street, Canberra City, A.C.T. In future years it is intended that applications will close about June 20.

University News:

Birmingham

The following appointments have been made: to the chair of botany, Prof. J. Heslop Harrison (for a note on Prof. Heslop Harrison's work see *Nature*, 173, 150; 1954); Dr. Brenda Manly and Dr. J. Cohen, lecturers in zoology; K. A. Redish, lecturer in mathematical physics; Dr. N. A. Dyson, lecturer in physics; Dr. F. J. Wallace, lecturer in mechanical engineering; Dr. I. R. Smith, lecturer in electrical engineering; Dr. V. G. Jenson, lecturer in chemical engineering; Dr. W. B. Morgan, lecturer in geography; R. S. Hall, Research Fellow in physics; E. A. Howson, Research Fellow in electrical engineering; R. D. Hartley, Research Fellow in mining; E. Whipp, G. E. C. Hirst Fellow in the Department of Electrical Engineering; A. T. Aldred, Research Fellow in physical metallurgy; D. W. Jones, Research Fellow in physical metallurgy.

Leeds

The following appointments to lectureships have been made: A. W. Chronowicz (civil engineering); Dr. B. F. Salvage (electrical engineering); A. L. Yettram (civil engineering).

Sheffield

The following appointments to lectureships have been made: P. Chadwick, applied mathematics; Dr. J. N. Murrell, chemistry; C. E. Blank, medical genetics Dr. J. Sykes, biochemistry; Dr. J. M. Hoskins, bacteriology and virology; Dr. J. Allison and Dr. A. M. Howatson, electrical engineering; K. Littlewood, fuel technology and chemical engineering; Dr. E. W. Lee, physics; L. Lehman, dental mechanics and prosthetics; T. B. Ferguson and J. D. Stringer, mechanical engineering; W. J. M. Tegart and C. W. Hawarth, metallurgy. Dr. J. F. Wallace has been appointed senior research fellow in mechanical engineering. The title of reader has been conferred on the following: Dr. A. Garnett, geography; Dr. D. R. Davies, applied mathematics; Dr. P. L. Pauson, organic chemistry.

St. Andrews

The following appointments have been made: to readerships, Dr. D. Bijl, lecturer in natural philosophy in St. Salvator's College, and Dr. A. J. O. Cruickshank, lecturer in electrical engineering in Queen's College. Senior lectureships are as follows: Dr. J. L. Copp, lecturer in chemistry in Queen's College; Dr. F. D. Gunstone, lecturer in chemistry in St. Salvator's College; Mr. W. McNicoll, lecturer in civil and mechanical engineering in Queen's College; Dr. A. R. Mitchell, lecturer in mathematics in St. Salvator's College; and Dr. F. Walker, lecturer in geology in Queen's College.

Announcements

Following the death of Sir Claude Gibb, it has been announced in the House of Commons that Sir Solly Zuckerman will succeed him as chairman of the committee responsible for controlling Government-financed scientific research and development. The committee was set up to consider the techniques and management of such projects.

Erratum. The papers referred to in the article entitled "Water-Resources and Water-Use Survey" in *Nature* of July 11, p. 96, are wrongly described in the footnote. The correct reference number is WMO No. 82.TP.32, which is published by the Secretariat of the World Meteorological Organization, Avenue de la Paix, Campagne Rigot, Geneva.

NATURE CONSERVATION AND YOUTH SERVICE IN BRITAIN

IN the past two reports of the National Parks Commission, appreciation has been expressed of the work done by volunteer groups in clearing disfigurements in the National Park areas in Pembrokeshire, Northumberland, the Lake District and the Peak District. When the Council for Nature was formed in 1958, it declared its intention of forming a volunteer group of young men and women to work in nature reserves and similar areas on tasks having the purpose of preserving the flora and fauna of the countryside. The Council's purpose in this project was twofold: on one hand, to help the many naturalists' trusts and other bodies in managing areas of scientific interest; and on the other, to offer young people in their spare time a task in the countryside which was worth while. This project was made possible by a generous grant from the Carnegie United Kingdom Trust, and in a paper read before Section X (Assembly of Corresponding Societies) of the British Association during the York meeting, Brigadier E. F. E. Armstrong, who has been responsible for the organization of this Volunteer Conservation Corps for the Council, described the scope of the Corps and some of the experience gained and problems encountered.

In contrast to the Civilian Conservation Corps of the United States, Brigadier Armstrong pointed out that the Conservation Corps is a volunteer spare-time activity, and the tasks undertaken had to be within the capacity of a group of young men and women working for the comparatively short periods they could give in holidays and vacations. Moreover, it was important that the task undertaken should have a viable ultimate scientific purpose, and should not be such that it would obviously be more usefully and efficiently done by machinery. Usually the tasks undertaken were those requiring manual rather than mechanical labour and suited to a group of volunteers, aged 16–23, working for periods of one, two or three weeks. In practice, the limiting factor had proved to be the financial resources, and not the availability of volunteers: some 400 volunteers had come forward against the 160 places that the Corps had been able to offer on 'residential' tasks, including week-end tasks and those occupying one or more weeks. Generally, the volunteers were from 'sixth formers' of schools, but university undergraduates and older members of natural history societies; 'Rovers' and 'Rangers' had also been anxious to help.

For the most part, volunteers were educated and already interested in natural history, and leadership could be formed on the site of the work, though the responsibility for the prior organization of the work rested with the headquarters organizer and the members of the body for whom the work is being done.

Brigadier Armstrong stressed the educational side of the work. The programme always included a daily evening lecture on some topic of nature conservation, followed by discussion, and efforts were made to include a visit to some other site of scientific interest in the neighbourhood and to any Nature Conservancy or Forestry Commission establishment within range. The education side had been much appreciated by the volunteers, and had clearly contributed to the success of the project. The Conservation Corps had already proved the existence of a very strong desire on the part of young men and women in Britain for an opportunity to assist in preserving the flora and fauna of the countryside.

Reference was made to the importance of satisfactory accommodation; for this year the Corps would have its own camp for a task exceeding a fortnight, while for other tasks accommodation had been obtained in youth hostels, a Field Studies Council hostel, a hotel and in H.M.S. *Conway*. Tasks already undertaken included clearing the dogwood and other scrub which has invaded and is overrunning the grassland slopes of Juniper Top, Boxhill; clearance work in a compartment of Woodwalton Fen to open it up for fenland flora and improve it as a habitat for the large copper butterfly; clearance of scrub in Askham Bog to show regeneration of plants and removing the top layer of vegetation to provide an area of more permanent bog conditions; clearing a path in Surlingham Broad to improve access to the centre of the Broad; and shelving down banks of ponds in Newborough Warren which had been excavated by machinery and planting suitable to consolidate these edges.

Brigadier Armstrong also referred to the development of week-end or single-day tasks, particularly in areas where plenty of volunteers are available and responsibility for organization could be delegated locally. Such tasks, which did not involve accommodation, were likely to be less expensive to organize and it was hoped to extend the development in future.

A following paper dealt with another problem also exercising concern both to the National Parks Commission and the Nature Conservancy. Breaches of the Country Code, damage to farm-land and in nature reserves is frequently done by teenagers from the big cities, seeking freedom from restrictions in the country and unaware of the dangers they themselves often run or the damage they do. Mrs. Edie J. Green, senior instructor of the Kyndwr Scwd Mountain Training Centre, Derbyshire, described a successful attempt to enlist the adventurous spirit of a group of such boys and to guide it into useful purposes. A start was made with a group of eight boys drawn both from those full of enthusiasm for outdoor activities but lacking skilled guidance, and from those responsible for vandalism, usually through sheer exuberance rather than deliberate destructiveness. Following essentially the principles laid down in another sphere by Elton Mayo and Mary Follett, and applied so strikingly by Lieut.-Commander A. H. Leighton in a Japanese re-location camp, the friendship of the boys was first won, and also the co-operation and goodwill of farmers and others in the district with whom the scheme would involve contact were secured. Then the boys were encouraged to frame their own rules and ultimately they produced a set of rules for the situation more impressive than the Country Code itself, breach of which was

punished, by the group's own decision, by sending the offender home. In practice, the rules were rarely broken, because to the boys they made sense.

From this it was an easy step to the acceptance of the Country Code itself, and the boys were often heard talking to their contemporaries about what should or should not be done in the country; and Mrs. Green suggested very reasonably that this is likely to have a far deeper effect than police warnings or slogans on the notice boards. With this went a changed attitude to farmers. Getting to know the farmers and understanding what farming meant changed the attitude of the boys into one of respect and co-operation: the farmer who had provided the site for the camp found his shippen cleaned out for him and a boy who admitted to knocking down dry-stone walls for years was found attempting to rebuild one.

Such changes alone would justify the continuance of such training camps from the point of view of the national parks and nature reserves alone, but the scheme also provided a definite programme for training the boys in climbing, in mountain rescue and in first-aid—at their own request. Here again the boys, from being a liability or a nuisance on the hills, became competent members of a mountain rescue team, and every challenge to endurance was met with enthusiasm. The experimental period described by Mrs. Green also showed the value of the scheme in developing the personalities of the boys. Much clearly depends on the quality of the staff, and there is also the matter of equipment; but the new training centre which opened in September 1959 offers a first-class mountaineering course for 5*s*. affiliation fee and 2*s*. 6*d*. at each school, and thirty boys are being taken.

APPLIED MATHEMATICS AND THEORETICAL PHYSICS AT CAMBRIDGE

A DEVELOPMENT in the University of Cambridge which will be of interest generally is the formation, from October 1, 1959, of a Department of Applied Mathematics and Theoretical Physics. The Department comes within the Faculty of Mathematics, and embraces the present teaching staff and research students on the applied side of the Faculty. Academic staff at Cambridge traditionally divide their time between centralized university lecturing and supervision of research students (as university lecturers, readers, etc.) on one hand, and informal teaching of undergraduates in their own college (as Fellows) on the other. This arrangement undoubtedly has advantages for undergraduates, but it has not been without some unfortunate consequences for research in a number of subjects. The various colleges provide their official Fellows with rooms, and the existence of this accommodation has retarded the development of centralized departments and buildings with adequate facilities for research. Teaching and research in the experimental sciences are impossible without a properly equipped laboratory, and these subjects were the first to be provided with central University buildings. Less obvious perhaps, but no less real, is the need for theoreticians to meet and work together in these days of rapid scientific developments and enlarging horizons. The formation of a Department of Applied Mathematics and Theoretical Physics at Cambridge is a recognition of this need, and is viewed as an administrative step towards the provision of central office accommodation and research facilities for the members of the Department. When that is achieved, an anomaly peculiar to the University of Cambridge will have been removed.

There are two novel features of the new Department. The first is that, as implied by the name, the Department includes both 'classical' and 'modern' aspects of theoretical physics and engineering science, in contrast to the usual plan in which applied mathematics and theoretical physics fall in separate university departments. This unity was suggested by the existing practice of teaching both applied mathematics and theoretical physics in the Mathematical Tripos; and it was in any event felt to be appropriate. The customary division between applied mathematics and theoretical physics is scientifically rather arbitrary (being prompted, perhaps, by the fact that in most universities applied mathematics is linked with pure mathematics and theoretical physics with physics) and is often unfortunate in its effects. Recent work on plasma physics and magneto-gas-dynamics has shown how much the two subjects have in common and how artificial is the division between them; and the older fields of theoretical astronomy and astrophysics have long illustrated the same point. The staff at Cambridge who will comprise the new Department are eighteen in number, and are engaged on work in elementary particle and field theory, nuclear physics, astrophysics, plasma dynamics, fluid mechanics and geophysics.

The second novel feature is the provision that the head of the Department shall be appointed for five years at a time from among the more senior people in the Department. This represents a deliberate departure from the practice in British universities of having a head with life tenure, usually the sole professor, or, where there is more than one professor, the one of greatest scientific distinction, and is more like the arrangement in many American universities. The disadvantages and risks of having a permanent head are well known; the health and fate of the department are tied to the administrative ability and capacity for leadership of one person for many years, the growth of a hierarchial structure may be encouraged, the talents of a rising leader may not be given full scope, and so on. There are also advantages, which may be more important in some circumstances; but there was a strong feeling at Cambridge that a more flexible scheme was desirable for the new Department. A period of five years was chosen as being long enough to allow the head of the Department to formulate and carry through any schemes which may be close to his heart, and short enough to be regarded as only a temporary interruption of personal research. The regulations allow re-appointment of a person for further periods of five years. This experiment in administration of a university department will be interesting and may have its lessons for other departments.

The first head of the Department is Dr. G. K. Batchelor, reader in fluid mechanics. He is known

for his work on the theory of turbulence and other branches of fluid mechanics, for which he was elected a Fellow of the Royal Society in 1957. Dr. Batchelor was born in Melbourne in 1920 and received his first degree from the University of Melbourne in 1940. Later he went to Cambridge, where he was elected a Fellow of Trinity College in 1947 and awarded an Adams Prize in 1951. He is editor of the Cambridge Monographs on Mechanics and Applied Mathematics and of the *Journal of Fluid Mechanics*.

ENZYMES

WAGENINGEN, situated on the Rhine in eastern Holland, contains 22,000 inhabitants, and about seventy institutes for scientific research. About one-half of these institutes form part of the State Agricultural University of Wageningen, while the other half are government or private institutes.

In these pleasant surroundings, a highly successful conference on enzymes was held by the University of Wageningen during April 6–9. The organizing committee was under the chairmanship of Prof. H. J. C. Tenderloo, with Dr. H. Veldkamp as secretary.

An introductory lecture was given by E. C. Slater (Amsterdam), who emphasized the central place of enzymology in biochemistry. In his view, it is enzymology which gives biochemistry its own methodology, and its own manner of thinking. (Later in the conference, H. Booij (Leyden), speaking as an 'angry young man', provided the necessary corrective against any over-enthusiastic adoption of this proposition by pointing out that other fields of biochemistry existed.) Although there are many different enzymes, the number of different reaction types catalysed by enzymes is quite small. Life, as we know it, involves comparatively few chemical tricks, which are used over and over again, and the aim of biochemistry is to systematize our knowledge of these tricks. A significant step forward in the systematization of enzymology was the appearance in 1958 of the book "Enzymes", by M. Dixon and E. C. Webb. Studies of the mechanism of enzyme action by kinetic and isotopic methods, and by direct chemical studies in which the enzyme is used as a reactant, have confirmed the suggestion made by Michaelis and Menten in 1913 that the enzyme reacts with at least one of the substrates to give an intermediate enzyme–substrate compound. However, in many cases the intermediate enzyme–substrate compound contains only a part, sometimes a small part, of the substrate. This lecture also dealt with the uses which have been made of isolated enzymes as tools in other investigations, in particular in analytical procedures and in the determinations of the structures of compounds isolated from natural materials, such as coenzyme A.

C. de Duve (Louvain) reviewed the recent knowledge of the localization of enzymes within the cell, which has been gained by fractionation of cell homogenates, particularly by differential centrifugation. He pointed out that although the cytologist would regard the preparation of a tissue homogenate as a brutal disruption of the cell, this homogenate is able to carry out very many reactions, and it is possible to localize different reactions in different cell organellæ which can be isolated from the homogenate. He dealt at length with the theoretical basis of the various methods of separation which have been used, and discussed their advantages and disadvantages. The use of 'marker' enzymes for the main fractions of the rat-liver cell nucleus, mitochondria, microsomes and 'soluble' fraction has led de Duve to the discovery that many hydrolytic enzymes are present in granules a little smaller than mitochondria which he has named lysosomes. More recent work using the technique of density equilibrium in heavy water has suggested that at least two enzymes (uricase and catalase) are present in yet another type of granule. The enzymes within the lysosomes are inactive towards their substrates unless the granules are destroyed mechanically or by suspension in hypotonic solution. The lysosomes also discharge their enzymes into the cell when the latter becomes anaerobic, thus promoting autolysis of the cell.

P. Desnuelle (Marseilles) spoke about the chemical structure of proteins and mechanism of action of proteolytic enzymes. He pointed out that although the chemical structures of insulin and of the polypeptides melanocyte-stimulating hormone and adrenocorticotrophic hormone are now established, the reason for the activity of the whole molecule is not yet known. He discussed what is known about the primary, the secondary and the tertiary structures of proteins, emphasizing that although other structures are theoretically possible, the open-chain is the only type which has been clearly demonstrated. Desnuelle described recent work on the activation of the precursors (the -ogens) of the pancreatic proteolytic enzymes, which has shown the importance of limited proteolysis in this process. Actually, the activation of chymotrypsin and trypsinogen is brought about by the splitting of a single bond. But this splitting is likely to be the first and necessary step for deep changes in the tertiary structure of the precursor, bringing two or three residues at the right position in space for building an 'active centre'.

E. C. Webb (Cambridge) surveyed the properties of the various coenzymes, prosthetic groups and activators of enzymes. He pointed out that metals sometimes act as carriers, sometimes promote the combination of the enzyme with the substrate. The effects of anion activators were discussed in relation to his own recent studies of the activation of arylsulphatase by chloride.

A discussion between Dr. Webb and Prof. Slater on whether a valid distinction could be drawn between a coenzyme and a prosthetic group led to the agreed definition that a compound acts as a coenzyme if during the course of its catalysis of the reaction it reacts first with one enzyme and then with another, and as a prosthetic group if it remains bound to the one enzyme during the course of the reaction. The same substance can in different reactions act as a substrate, a coenzyme or a prosthetic group.

Sir Rudolph Peters (Cambridge) discussed enzyme inhibitors, illustrating the different types by reference to carbon–fluorine compounds (for example, fluorocitrate), arsenicals and organo-phosphorus compounds. The recent studies at Babraham on the mechanism of the inhibition of aconitase

by fluorocitrate were presented. In the discussion of arsenical inhibitors, emphasis was placed on the different actions of monosubstituted (for example, lewisite, mapharside) arsenicals, which inhibit pyruvate oxidation, and disubstituted (for example, diphenylchlorarsine) compounds which inhibit isocitric dehydrogenase, as well as on the practical application of 2,3-dimercaptopropanol in reversing the inhibition by arsenicals.

The organo-phosphorus inhibitors were discussed in relation to their action on cholinesterase, and to the reversing effect of pyridine-2-aldoxime methiodide. As an example of antimetabolites, Sir Rudolph discussed the antagonism of the effect of serotonin by 1-benzyl-2,5-dimethyl-serotonin.

F. Dickens (London) discussed the regulation of enzymic reactions within the cell with special reference to carbohydrate metabolism. Regulation can be provided by structural barriers within the cell, but also by enzymic mechanisms which do not require structural separation of reactants. Examples of the latter type are given by: (1) control of rate of mitochondrial respiration by the concentrations of inorganic phosphate and adenosine diphosphate; (2) 'feedback' by inhibition of the enzyme by the product of the reaction, for example, inhibition of hexokinase by glucose-6-phosphate; (3) the existence of different mechanisms for breakdown and synthesis, for example, the equilibrium of the uridine diphosphoglucose pathway of glycogen synthesis is much more favourable to synthesis than is the reversal of the phosphorylytic breakdown. Dickens directed attention to situations where the pentose phosphate pathway is particularly active in relation to glycolysis, for example, in the lactating mammary gland, where its function is probably to provide reduced triphosphopyridine nucleotide for fat synthesis, and in the lens where its function is possibly to provide the same compound to keep glutathione reduced.

H. Chantrenne (Brussels) concluded the conference by a discussion of the present status of the investigation of the mechanism of protein synthesis in general, and of enzyme synthesis in particular. He pointed out that the earlier sharp distinction between adaptive and constitutive enzymes has been abandoned. The recent work of Ingram on abnormal hæmoglobins has shown that even the fine details of the protein structure are controlled by the gene. A mutation of a single gene causes a change of one amino-acid in the polypeptide chain. It is conceivable that the deoxyribonucleic acid of the gene contains the information which determines the sequence of amino-acids in the protein chain. This information must be transferred to the ribonucleic acid in the cytoplasm, where the protein is synthesized. The function of the inducer, the presence of which is necessary for formation of an enzyme, is not known. However, it has been shown that it acts in catalytic amounts, not autocatalytically. This suggests that it acts on an enzyme-synthesizing mechanism which is already present, perhaps in an inhibited form. In the discussion of this paper, Desnuelle pointed out that enzyme activity requires a specific configuration (tertiary structure) of the polypeptide chain. The native form of an enzyme is a unique, unstable structure among many more stable structures. It is, therefore, likely that not only the arrangement of the residues along the chains but also the specific folding of these chains are gene-controlled. This must be taken into account in any consideration of enzyme synthesis.

An unusual feature of this conference which had much to recommend it was that the programme called for only two speakers each day, one in the morning and one in the afternoon. This enabled the speakers to give a long introduction (about 45 min.) for the benefit of non-specialists, before a coffee or tea break, after which the speaker continued for a further 30–45 min. A discussion then followed.

E. C. Slater

ENERGY TRANSFER WITH SPECIAL REFERENCE TO BIOLOGICAL SYSTEMS

THE mechanisms by which energy may be transferred from one atom or molecule to another have become a prominent theme of chemical kinetics, photochemistry and radiation physics—as well as of many biological processes. The same fundamental processes and many of the outstanding problems are common to each of these sciences, and those of biological systems, in particular, depend for their solution on development in other fields. The efficiency and generality of energy transfer between molecules has been fully appreciated only quite recently, and the discussion on this subject, which was held by the Faraday Society at the University of Nottingham during April 14–16, was one of those timely meetings for which the Society is noted. It was attended by two hundred physicists, chemists and biologists, about one-quarter of whom were from overseas.

The discussion was divided into two parts, the first concerned with energy transfer processes in general and the second with their occurrence in biological systems. After the president, Dr. E. W. R. Steacie, had welcomed the overseas visitors, the Spiers Memorial Lecture on "Transfer Mechanisms of Electronic Excitation" was delivered by Prof. Th. Förster, of the Technischen Hochschule, Stuttgart. This provided an excellent introduction to the first part of the discussion, which was concerned almost entirely with this topic. The transfer of electronic excitation energy from one molecule to another can be a very efficient process which may occur, not only at every encounter, but even over distances of 50 A. or more. Apart from the 'trivial' process involving emission and re-absorption of light, this transfer can proceed by a radiationless mechanism known as resonance transfer, the interaction between the molecules being one of dipole–dipole coupling and not overlap of electron orbitals which is significant only at much smaller distances. The process is often also referred to as the Förster mechanism, and Prof. Förster gave a clear account of the quantitative theory which he, principally, has developed. He

discussed the application of the theory to forbidden transitions, transfer within one molecule and between like molecules, and pointed out that conditions for excitation energy transfer are very favourable in biological systems since Nature often prefers a high local concentration of absorbing matter.

The first four papers of the discussion were all concerned with electronically excited organic molecules. Prof. G. Porter and Dr. M. R. Wright (University of Sheffield) discussed processes of deactivation involving change of multiplicity. In particular, they presented rate constants for the decay of triplet states of aromatic molecules in solvents of varying viscosity and in the presence of paramagnetic molecules and ions and gave an interpretation of the latter process in terms of overall spin conservation rather than magnetic perturbation of spin-orbital coupling. Dr. A. Weller (Technischen Hochschule, Stuttgart) described his work on the reactions of excited singlet state molecules, with particular reference to acid-base equilibria and proton transfer in the excited state. Dr. B. Stevens (University of Sheffield), in the only paper dealing with the vapour phase, described experiments which showed that transfer of energy from electronically excited benzene to anthracene occurred over an average distance of 7·6 A. Dr. E. J. Bowen (University of Oxford) described fluorescence studies of the excited singlet states of anthracene derivatives, with particular reference to the influence of temperature and solvent viscosity. The data indicate that two processes of radiationless conversion—probably to triplet and ground state—are operative.

There was much discussion following these papers, most of which was about radiationless transitions and particularly the effect of viscosity upon them. Prof. Porter had interpreted this effect in terms of different configurations of the two states, and Dr. Bowen's explanation involved the attainment of a certain amplitude of vibration. Prof. H. C. Longuet-Higgins (University of Cambridge) thought that it was the removal of energy by the solvent which was important and that the greater efficiency of solvents of low viscosity was a result of their having the lower-frequency components necessary for this transfer. Dr. D. H. Whiffen (University of Birmingham) suggested that it is molecular rotation which is important and that a time-dependent mixing of singlet and triplet states is introduced by interaction between rotation and spin-orbit coupling. Prof. J. D. Bernal (Birkbeck College, London) pointed out the importance of structure and the inadequacy of viscosity as a measure of microscopic properties—a point which was emphasized by other speakers. No general agreement was reached on these alternative theories in spite of the very valuable discussion.

The second scientific session began on the morning of April 15, with four papers on electronic energy transfer in solution. Dr. F. H. Brown, Dr. M. Furst and Prof. H. P. Kallman (New York University) gave an account of their extensive work on energy transfer in rigid and liquid organic scintillator systems induced both by light and by ionizing radiations. In these solutions as much as 10 per cent of the energy absorbed by the bulk material is emitted by the solute, and three mechanisms, in addition to the radiative one, are involved under various conditions. These are : (*a*) material diffusion transfer (in liquids only) ; (*b*) migration transfer ; (*c*) single step transfer. Dr. J. B. Birks and K. N. Kuchela (University of Manchester) described similar studies in polystyrene solutions as a function of wave-length. At concentrations greater than 10^{-4} molar the transfer was found to be non-radiative. Prof. M. Burton and H. Dreeskamp (Notre Dame University) described the measurement of luminescence decay times in scintillator systems by a method utilizing X-ray pulses of about 10 mμsec. duration and concluded that the measured decay times were characteristic of excitation transfer processes. Prof. M. Dole (Northwestern University, U.S.A.) and Dr. T. F. Williams (Atomic Energy Research Establishment, Harwell) described further studies of the disappearance of unsaturated linkages on γ irradiation of polyethylene, the high *G* value of which shows that energy transfer processes must be operative.

In the discussion on these papers, Prof. Kallman pointed out that the life-time of anthracene vapour molecules is shorter by an order of magnitude than that found in condensed phases, which Bowen suggested might be due to the fact that emission involves higher vibrational states of the excited gaseous molecule. Dr. Stevens said that the longer measured life-time in condensed media was probably due to re-absorption effects, a view shared by Birks, who emphasized that the 'molecular' life-time in condensed phases is as short as that found in the gas. Prof. Burton warned against over-confidence in values obtained by the phase-shift technique, since analysis of the data assumed an exponential decay which may not always be observed.

Dr. A. Szent-Györgyi introduced the papers on "Energy Migration in Biological Systems" with a summary of the various ideas that have been introduced in the past fifteen years : semiconductivity, resonance energy transfer and electron transport. Dr. Szent-Györgyi dealt more specifically with the electron flow in the respiratory chain and introduced a suggestion of his own, namely, that the partial charge transfer complexes that have been intensively studied during the past few years are the first steps in the one-electron oxidation processes that Michaelis first postulated.

These various aspects of energy transfer were dealt with in detail in the papers that followed : M. H. Cardew and Prof. D. D. Eley (University of Nottingham) reported measurements on the semiconductivity of amino-acids, hæmoglobin and globin. Their findings of small conductivity with activation energies of the order of 3 eV. are in agreement with the values expected for a hydrogen-bonded CO . . . HN system. R. Mason (University College, London) described some possible instances of charge transfer in proteins, which have not yet found empirical foundation. Dr. G. Weber and F. J. W. Teale (University of Sheffield) reported on energy transfer in the hæm proteins which results in the quenching of the tryptophan fluorescence of the native proteins and of the fluorescence of a conjugated group in hæm–protein conjugates. The results, which are in general agreement with Förster's theory, permit some conclusions about the distribution of the hæms on the surface of hæmoglobin. A paper by Prof. Q. H. Gibson (University of Sheffield) described how hæmoglobin formed from CO-hæmoglobin by a light flash had a much greater reactivity towards carbon monoxide than the ordinary hæmoglobin into which it reverted spontaneously with a rate of 200 $sec.^{-1}$.

Four papers dealt with energy migration in photosynthesis. The background to the problems was presented by Prof. B. Rabinowitch and Dr. S. S. Brody (University of Illinois), who pointed out the

unique structural features of the chloroplast as revealed by the light and electron microscopes and the difficulty, if not the impossibility, of reproducing these features in our simple model systems. When the probable ways of energy migration in the chloroplast are considered the resonance transfer among some 200 chlorophyll molecules forming a photosynthetic unit appears the most likely. Prof. R. Lumry (University of Minnesota) presented work by himself, J. D. Spikes and B. Mayne in which simultaneous measurements of Hill reaction velocity and fluorescence yield were carried out. The parallelism of the two phenomena strongly favours the idea of a trapping centre to which the energy is transferred by resonance after its absorption by chlorophyll and where it is utilized in competition with the fluorescence and other radiationless deactivation processes. A paper by Dr. L. N. M. Duysens and J. Amesz (University of Leyden) dealt with the quantum requirements of diphosphopyridine nucleotide in photosynthesis. From this paper, as well as the previous work of Dr. Duysens on the oxidation of cytochromes, and from recent data that Prof. Britton Chance and T. Yonatani (University of Pennsylvania) presented in the course of the discussion, in which fast simultaneous recordings of cytochrome oxidation (by absorption) and diphosphopyridine nucleotide reduction (by fluorescence) were obtained, it appears now certain that the simultaneous oxidation of cytochromes and reduction of diphosphopyridine nucleotide are among the earliest events in photosynthesis. Prof. R. Livingston (University of Minnesota) and Prof. A. Terenin, E. Putzeike and I. Akimov (University of Leningrad) dealt with properties of isolated chlorophyll, namely, the quenching of the triplet state and the photoconductivity, respectively. Dr. W. A. Hagins (National Institutes of Health, Bethesda) and W. H. Jennings (Duke University, U.S.A.) presented experiments which showed the localization as opposed to migration of the excitation in the retinal rods, while M. J. Cowan, J. M. F. Drake and Dr. R. J. P. Williams (University of Oxford) examined chelates of iron as models for the understanding of the variations in spectrum and redox potential of the cytochromes.

A paper by Prof. Britton Chance and E. L. Spencer (University of Pennsylvania), which described the rapid establishment of redox equilibria in the cytochromes of cells and cell particles at the temperature of liquid nitrogen, was interpreted by the authors as suggesting a solid-state mechanism of electron flow among the cytochromes.

Prof. D. E. Green (University of Wisconsin) concluded from the analysis of linked respiratory chain reactions that the electron transport is essentially a solid-state process occurring in a lipid phase; but the discussion that followed this paper showed that the evidence was not regarded as in any way conclusive.

In a discussion of energy in the biological systems, adenosine triphosphate could not be omitted. Although no paper dealt specifically with the properties of adenosine triphosphate, these were the subject of a lively discussion. Briefly, some speakers thought that adenosine triphosphate has had greatness thrown upon it by the accident of evolution, a distinction which may just as easily have fallen on its humble cousin pyrophosphate. Others believed that the rest of the molecule will be found to be indispensable in energy transfer. Prof. J. A. V. Butler (University of London) summarized the evidence for the first view. Dr. J. H. Turnbull (University of Birmingham) put forward the case for the latter.

The past twenty years have seen great improvements in the methods that reveal the purely structural features of biological systems. Because of their success we have come to look for explanations of biological events in terms of structural factors alone. The energetic aspect is equally important and indeed complementary to the structural, and this meeting rendered a good service to the biological sciences by bringing attention to this often neglected point.

G. Porter
G. Weber

HEATING BY ELECTRON BOMBARDMENT

Electron bombardment heating is produced by accelerating electrons from a thermionic cathode on to a specimen, by means of a d.c. voltage. Simple focusing of the electron paths enables the heating to be highly localized and melting is achieved with very small power requirements. These facts, together with an ease of power control and the necessity for vacuum operation, explain the preference for heating by electron bombardment in some applications. Although used for very many years, it is only recently that this method of heating has become more widely known through its application to the melting of refractory metals for the purpose of floating-zone melting[1], welding[2,3] and evaporation[4]. The growing interest in this technique was shown by the attendance of one hundred and sixty visitors, from British and overseas laboratories, at a symposium on "Electron Bombardment Floating-zone Melting and Allied Electron Bombardment Techniques", held at the Services Electronics Research Laboratory, Baldock, Herts, on March 10.

Several papers on electron bombardment floating-zone melting were given. In this method, a rod of the material being purified is held at both ends in a vertical position and a molten zone is induced in it by bombarding it with electrons from a circular cathode. The molten zone is held stable by surface tension and this imposes an upper limit[5] on the maximum zone length, and hence diameter, of the specimen to be zoned. Relative longitudinal movement between the cathode and rod moves the zone along the rod and zone-refining takes place. The purified rod often becomes a single crystal. Metals sometimes out-gas violently when melting for the first time in a vacuum, and a bombardment-current controller[6,7] is necessary to stabilize the current, which tends to fluctuate under these conditions. Whereas vacuum operation is advantageous when zoning reactive metals, it has the accompanying disadvantage that considerable material may be lost by evaporation. This has led most experimenters to use zone travel speeds which are too fast for segregation of impurities, and purifica-

tion is obtained mainly by evaporation of the lower melting point impurities from the molten zone and by out-gassing *in vacuo*. A criticism of the method is that contamination of the specimen by the cathode can occur and is occasionally detected. This can sometimes be overcome by using a cathode of the same material as the specimen, for example, tantalum, rhenium, or by designing a cathode system which 'hides' the cathode from the molten zone. No speaker reported any experiments on this aspect.

A. Calverley (Services Electronics Research Laboratory, Baldock, Herts) described an improved electron bombardment apparatus[8] which overcame the limitations of poor operating vacuum, visibility and speed range of his earlier apparatus[6]. The main features of the new apparatus are similar to those of the Services Electronics Research Laboratory silicon crystal puller[9], and zone-refining of refractory metals and semiconductors can be done in a vacuum of $\sim 10^{-6}$ mm. mercury and sometimes better. Of great practical value is the ability to move vertically up or down that part of a specimen below the molten zone during the zone-refining operation. This enables variations in the diameter of the specimen, which occur during preliminary out-gassing, to be corrected and it can also be used for determining the length of the molten zone, for with some metals it is difficult to see the boundary between the solid rod and liquid zone. With low melting-point metals such as aluminium, gold and copper, stable zones are difficult to maintain, but no difficulty is experienced with the more refractory metals. Work with the earlier apparatus was of an exploratory nature and single crystals of tungsten, rhenium, tantalum, molybdenum, rhodium, niobium, iridium, ruthenium, platinum and nickel were made ranging in size from 2–5 mm. diameter and up to 18 cm. long. The properties of these crystals are often found to be much closer to those of a perfect metal than was the case with the best specimens previously available. For example, zone-melted molybdenum was found[10] to have the same tensile ductility at − 196° C. as arc-melted molybdenum at − 30° C., and the superconducting properties of tantalum prepared in this way were found to be quite close to those of an ideal superconductor[11]. At the moment, work with this apparatus is concentrated on producing pure crystals of tantalum, vanadium and niobium for superconductivity studies, these metals being obtainable with Vickers hardness numbers 68, 79, and 38 respectively. The smallest specimen so far zoned is a 0·060 in. diameter tantalum rod. With alloys, the ability to zone-melt them depends on the vapour pressure of the constituents at the melting point of the alloy. Thus whereas tantalum–niobium alloys may be zoned, tantalum–vanadium alloys of high tantalum content cannot be melted without almost complete evaporation of the vanadium. Although possessing a high resistivity at room temperature, boron can be zone-melted providing a short electrical conduction path is maintained for the initial heating of the specimen, that is to say, if the bombarded region is within 2–3 cm. of the specimen holder. Once the temperature of the boron rises, its resistivity drops and normal zoning can take place. Boron is prone to thermal shock fracture so that heating, cooling and traversing of the specimen has to be done slowly.

F. O. Jones (Associated Electrical Industries, Ltd., Research Laboratories, Aldermaston) has prepared molybdenum–rhenium (50/50) and uranium–zirconium (70/30) alloys and concludes that, providing the vapour pressure of a constituent of an alloy is less than 10^{-3} mm. mercury, the alloy can be zone-melted without undue loss. A description of preliminary work on molybdenum–rhenium alloys was given by A. Lawley (University of Pennsylvania). His apparatus differs from that of the other speakers at the symposium in that it is a typical bell-jar system with all components mounted on a common base-plate.

Molybdenum crystals up to $\frac{1}{2}$ in. in diameter have been grown by J. A. Belk (Armament Research and Development Establishment, Fort Halstead), moving the zone up a rod of swaged arc-cast material. Their axes were in the section of the unit stereographic triangle bounded by (001), (101) and (112). Tensile tests showed an absence of a sharp yield-point at the pure end, and there was a reduction of carbon from 0·008 to 0·002 weight per cent. A more sensitive method of analysis is required before any conclusions of the movement of carbon by zone-refining could be drawn. The zone-melted material showed very much lower impact transition temperatures than arc-cast molybdenum, both in single crystal and polycrystalline form. For a carbon content of 0·002 weight per cent the values were − 140° C. and − 50° C. respectively. Alloys of molybdenum with tungsten had been produced either by sintering and zone-melting a powder compact, or by melting a molybdenum rod with a close wound helix of tungsten wire. Some preliminary experiments on electron beam melting[12] were reported. In this technique, molten drops from the lower end of a bombarded rod are allowed to fall into a cooled crucible and ingots of large diameter of vacuum-melted material are produced in this manner. The experiments indicated that the power requirements were at least double those required for floating-zone melting. Out-gassing of the rod assumed much greater importance due to the increased rate of melting, and an emission-current limiter was required in addition to the normal type of emission-current controller.

F. O. Jones described his work on carbides and has found that titanium carbide (TiC) and tungsten carbide (WC) decompose at temperatures lower than their melting points. Tungsten carbide (W_2C) melted but decomposed with loss of carbon, and tantalum carbide (TaC) partially melted but also decomposed with loss of carbon. A. Calverley has found that vanadium diboride likewise decomposed with loss of vanadium.

Work on cobalt has been carried out by H. Uwents (Rijks Universiteit, Gent). After 10 passes at a zone speed of 30 cm./hr. on a 0·5 cm. diameter cobalt rod, he obtained a specimen which, after etching, revealed a small number of relatively large grains. X-ray diffraction photographs on either side of what appeared to be grain boundaries yielded the same diffraction patterns, from which he concluded they were in fact sub-boundaries. It seems possible to grow single crystals of materials which have a transformation point, by zoning at temperatures slightly higher than the transformation point.

The contribution of D. W. Rhys (Mond Nickel Co., London) was concerned with the electron bombardment floating-zone melting of platinum, ruthenium, rhodium and iridium, interest in this technique for the last three metals resulting from the lack of ductility normally encountered at room temperature. Analyses of a platinum bar zone-melted twelve times at 60 cm./hr. showed that major purification occurred

by preferential evaporation of impurities, but there was nevertheless evidence of zone segregation, though at this high rate of traverse the process was inefficient. Contamination of platinum by tungsten from the filament can occur, and in some instances the product may be inferior to the starting material. Ruthenium single crystals prepared by the method can be bent readily but have not yet been cold worked successfully, and analyses of zone-melted bars have shown that purification occurs chiefly by preferential evaporation. A rhodium single crystal bar prepared by zone-melting could be cold swaged to a 90 per cent reduction in area but on subsequent annealing became polycrystalline and possessed negligible cold ductility[13]. Iridium single crystals prepared by the method are also more ductile than the polycrystalline material and, in this metal, zone segregation of nickel was observed, though the majority of impurities were reduced by preferential evaporation.

W. P. Allred (Battelle Memorial Institute, Ohio) also reported on the zone-refining of the platinum-group metals. He finds that zone speeds of 7·5 cm./hr. give little segregation of impurities whereas a speed of 1·25 cm./hr. gave very effective segregation, reducing most of the impurities below the spectrographic limit. Vacuum fusion analyses show the oxygen, hydrogen and nitrogen content to be as low as from 7 to less than 0·2 p.p.m.

One cannot bombard an insulator continuously with electrons because the electrons are unable to escape from the bombarded region, and the potential difference between cathode and target is reduced to zero. To overcome this difficulty, the insulator is bombarded at a voltage such that the ratio of secondary to primary electrons is greater than unity, and a secondary electrode is arranged to collect the secondary electrons. A communication was sent to the symposium by T. Bridges and R. Strnad (Bell Telephones Laboratories) describing their work on zone melting of single-crystal sapphire rod 0·1 in. in diameter. They find that the bombarding voltage is restricted by the above condition, the vapour pressure is high and power requirements for a completely molten zone are much higher than those for surface melting only.

Talks on other applications of heating by electron bombardment followed those on zone-melting. G. W. Warren (General Electric Co., Research Laboratories, Wembley) described the out-gassing of molybdenum in the solid state at a pressure less than 10^{-7} mm. mercury. The molybdenum specimen and bombarding system are mounted in a glass envelope which is baked and sealed-off from the pumping system after firing a barium getter. The air-cooled barium film absorbs any gas evolved from the molybdenum, which after heating for 8 hr. at 2,100° C. has an oxygen content of 1 p.p.m.

With floating-zone melting, a rod which is held at the ends only can only support one molten zone. To obtain the advantages of multiple-zone melting, P. le Couteur (General Electric Co., Research Laboratories, Wembley) used horizontal zone-melting to purify germanium. Focused electron bombardment enables narrow zones, another pre-requisite of efficient zone-refining, to be obtained. The use of a vacuum instead of a gas ambient has further lowered the ultimate impurity distribution.

Analysis of zone-refined specimens has placed fresh problems on the analyst. C. A. Parker (Admiralty Materials Laboratory, Holten Heath) reviewed the present methods available for analysing high-purity materials. One of the main problems is to obtain reagents which are as pure as the material being analysed. To avoid the use of reagents, one can either use emission spectroscopy or solid-source mass spectrometry and these have in favourable cases a limit of detection of 1 in 10^8. To investigate impurity-levels lower than this, it is necessary to label the impurity atom within the sample before carrying out the analysis. The most commonly used method is to expose the sample to a flux of thermal neutrons by inserting it into an atomic reactor. The atoms become radioactive and impurities can be separated out by chemical treatment. Any contamination by corresponding impurities in the reagents has no effect on the subsequent Geiger counter reading. The sensitivity for this type of analysis may be as low as 5×10^{-12} gm.; but unfortunately for some elements, either the neutron absorption is too low or the isotope produced has too short a life-time. However, proton activation is being developed as an alternative to neutron activation for some of the light elements. The principle here is the same, but instead of labelling the impurity atoms by irradiation with neutrons, they are exposed to a beam of high-energy protons from a cyclotron. Using this method, quantities of boron in silicon can be determined down to 1 part in 10^9. Activation analysis by protons and other particles such as deuterons is still in its infancy, but it seems likely that methods for the determination of other light elements, including oxygen and nitrogen, will be developed in due course.

The ease with which a molten drop of metal can be produced on the end of a vertically suspended rod using electron bombardment heating had made possible the determination of the surface tension of refractory metals at their melting point. A. Calverley described his drop weight surface tension measurement of liquid tungsten[14]. His value of 2,300 dynes/cm. is approximately 380 dynes/cm. less than Taylor's estimated value[15]. A solitary determination for tantalum gave 2,020 dynes/cm., which is 310 dynes/cm. less than Taylor's value. However, J. C. Kelly (Atomic Energy Research Establishment, Harwell) has used the sessile drop method for one determination only and obtained a value for tantalum which is in agreement with Taylor's value.

J. C. Kelly described the evaporation of thin films of tantalum and zirconium[4] from a pendant drop on the lower end of a vertical rod. A simple arrangement of focusing plates enables contamination by the cathode of the drop or the target to be avoided. He has observed that, above a certain temperature, oscillations of the pendant drop occur. The rate of evaporation from pendant drops bombarded with electrons is the subject of a recent paper by Heavens[16]. Its application to 'Evaporion' pumps was discussed by L. Holland (Edwards High Vacuum, Ltd., Crawley, Sussex).

A silicon crystal pulling furnace using heating by electron bombardment was described by D. B. Gasson (Associated Electrical Industries, Ltd., Aldermaston). A central pool of molten silicon in a randomly shaped silicon charge resting on a water-cooled hearth is maintained by beams of electrons from four guns situated approximately 12 in. above the silicon to reduce mutual contamination. Each beam can be focused individually and its power varied. This obviates the need for seed rotation because the thermal condition of the melt can be varied at will. The oxygen content of crystals prepared in this furnace is similar to that found in

silicon rods prepared by floating-zone melting in a vacuum or dry hydrogen.

The construction of nuclear fuel elements necessitates the welding of a variety of reactive metals and their alloys, such as zirconium, titanium, molybdenum and beryllium. Welding by electron bombardment heating[2,3] has been found to give a better-quality weld for most metals than welding in an inert gas. P. Thomé (Centre D'Etudes Nucléaires de Saclay, France) described various electron guns in which the electron beam is focused to a target spot ranging in diameter from 0·01 mm.² to 0·3 mm.² for 20 m.amp. and 1 amp. bombarding currents respectively at 20 kV. The beam of electrons passes through a hole in an earthed screen situated close to the components being welded, which are also at earth potential. This reduces the risk of glow discharge and arcing when fusion occurs. A further advantage is that there is no variation in the focus size with different shapes of pieces being welded. With the use of pulse heating, it is possible to apply a very high power to a small area and, if the speed of the work-piece is correctly related to the frequency of beam chopping, the weld consists of a series of overlapping spots. This permits a greater weld penetration and avoids the collapse of the sides of the weld due to metal flow which may happen in continuous welding, and also minimizes the area of recrystallization.

The general impression left by the conference was that in spite of some fundamental disadvantages, heating by electron bombardment will continue to play an important part in the science and technology of the more refractory metals and insulators, and will undoubtedly find other applications in high-temperature researches. A. CALVERLEY

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TRANSISTOR CONVENTION AND EXHIBITION

AN International Convention on Transistors and Associated Semiconductor Devices was held at Earls Court, London, during May 21–27. The Convention was organized by the Electronics and Communications Section of the Institution of Electrical Engineers, which also promoted the International Transistor Exhibition held at Earls Court during the same period. The opening lectures were given by Prof. J. Bardeen, Dr. W. H. Brattain and Dr. W. B. Shockley. Some thirty further lectures were distributed among the eleven general and eleven specialist sessions that followed (mostly two at a time in parallel), brief summaries were presented of some eighty original papers, and some thirty-seven further original papers, of which either the full text or a brief digest had been previously circulated to those attending the Convention, were taken as read. The discussions at the sessions were rarely lively, perhaps because of the size and formality of the meetings and the acoustical defects of the halls (it was surprising not to find transistorized roving microphones provided to overcome this difficulty).

In his lecture Shockley considered the factors limiting the capabilities of the 'transistor-diode'—a silicon transistor operated without external base connexion up to voltages at which avalanche multiplication at the collector junction compensates for the initially low injection efficiency of the emitter—as a fast switch for heavy currents. The tendency (due to the transverse ohmic voltage drop in the base region) for part of the emitter junction to draw to itself current from the rest could be overcome by switching on quickly enough after ensuring (by a suitable controlling wave-form) that the whole of the emitter is first just-sufficiently turned off. As an example an oscillogram was shown of a current pulse rising to 50 amp. in 20 μsec. across a load of about 0·5 ohm. In a separate paper Shockley showed that the minimization of the total capacitance of the emitter junction (also necessary in the device just considered) requires an optimum finite depletion layer thickness, on account of carrier storage in the layer.

Pritchard's lecture brought out the unsatisfactoriness of present commonly used equivalent circuits for transistors, particularly as regards the representation of the base resistance. Linvill generalized the Thevenin and Norton representations of a 2-terminal network to cover 2-ports, including the effects of internal 'contamination' generators representing, for example, noise or the dependence on temperature of d.c. parameters, and showed how the choice of an optimum source impedance could be solved generally for each of the last two situations. J. J. Sparkes showed that for some proportion of transistors the components $C_{b'e}$ and $G_{b'e}$ of the hybrid-pi equivalent circuit depart from their expected dependence on frequency, and suggested that the departures could be accounted for in terms of minority-carrier storage either in the emitter region or laterally in the base region. The effect could be correlated with anomalies in the switching characteristics.

The concept of charge-control (in contrast to current-control as generally considered typical of a transistor and voltage-control of a vacuum tube) was applied in detail by Beaufoy and by Kruithof to the quantitative description of the switching characteristics of transistors, and a generalized justification of the concept was presented in the lecture by Prof. Middlebrook.

Several papers set out to consider costs as related to some of the combinations of technologies now

possible in the manufacture of transistors in large quantities. Although full agreement was lacking (not surprisingly, in view of the different markets and different degrees of reliability sought), a consensus of opinion seemed to favour one or other form of 'mesa' geometry, using diffusion alone or together with alloying, as the structure of the future. By the use of 'photo-lithographic' or other masking methods, large numbers of junctions could be completed simultaneously on each wafer of germanium or silicon, leaving a minimum of handling for the mounting and encapsulation of the individual transistors.

Atalla reported experiments on the electrical stability of silicon surfaces on which a thick (300 A. or more) oxide layer had been grown by exposure to water vapour or oxygen at about 1,000° C. Such surfaces showed exceptional freedom from effects usually ascribed to changes in the density or nature of 'slow' electronic trapping states on the outer surface of the oxide ; a reversible creep effect observed for a humid ambient in the leakage current of a p–n junction having such a surface treatment was ascribed to the inversion layer induced in the underlying silicon on one side of the junction by the mobile ions electrolytically separated in the adsorbed water film as a result of the bias voltage applied across the junction. The oxide layer itself could withstand some 0·1 V. per angstrom of thickness and should preferably be made thick enough to support the full breakdown voltage of the bulk p–n junction.

The reliability of complete devices was considered explicitly in two papers, one of which showed that the activation energy for the ageing mechanism for a particular type of p–n–p alloyed germanium unit was about 1·2 eV., the end of useful life being brought about by the onset of rapid increase in leakage current and noise in a way characteristic of attack by water on the germanium surface.

A number of papers were devoted to the electrical parameters of semiconductor devices, and to their measurement. The frequency limitation (at about 1,000 Mc./s.) set by the base width of transistors could be avoided by using single junction devices such as the variable-capacitance diode, and the diode proposed by Esaki in which the depletion layer is so thin as to allow tunnel effect to dominate the behaviour at low forward biases. It was necessary in high-frequency measurements to bring the point of measurement as close as possible to the envelope of the device. Measurements in the switching field were dominated by the charge-control approach, which uses rectangular wave-forms and CR networks.

Sixty-four papers were devoted to applications ; computers and switching applications were much the most prominent. Here the low power consumption and promised high reliability of transistors were seen to be of paramount importance, particularly as the earlier limitations on speed of operation were being largely overcome by developments in high-speed switching transistors. Chaplin illustrated the use of selected high-frequency alloy transistors (having a cut-off frequency of current gain of only about 10 Mc./s.) in the avalanche mode to generate pulses with times of rise of the millimicrosecond order.

Second in prominence to computers was the field of communications ; here once again the transistor could reduce the size and power consumption of both mobile and fixed equipment and sometimes obviate the need for buildings. A paper by Grosser on space-division electronic telephone exchanges illustrated the important part that the $pnpn$ structure can play as a substitute for a cross-point switch. Cave, Neu and Sim have used some specially made point-contact germanium diodes as variable reactance modulators to control up to several hundred milliwatts of power at millimetre wave-lengths, with switching times as low as 3 mμsec.

Power diodes, silicon four-layer controlled rectifiers, and power transistors were all being applied to power supply and control. Besides emphasizing the small size and high efficiency of these devices, papers directed attention to the protection problems arising from the rapidity with which damage can occur.

In instrumentation, the diverse properties of semiconductors were being applied to a very wide range of applications. There were papers on the design of Hall effect multipliers, and also on single-crystal infra-red detectors using intermetallic compounds. Klein and Straub suggested that fast-neutron dosimetry could be carried out by electrically assessing the damage caused in germanium and silicon, and proposed an assembly of high-resistivity p-type germanium and lithium-6 for thermal-neutron dosimetry. McKenzie and Bromley dealt with the use of gold–germanium junctions as proportional particle spectrometers having a fast rise-time (< 3 mμsec.).

The exhibition was very well staged and paid due attention to research and up-to-date development as well as more conventional technology. The many pieces of equipment using transistors illustrated well their versatility and wide field of application. The exhibition showed also the extent to which industries ancillary to semiconductor technology, producing equipment such as furnaces, radio-frequency heaters, air-conditioning equipment, control instrumentation, etc., and supplies of high-purity material, are springing up. Among the newer semiconductor devices were mesa transistors from the United States and four-layer controlled rectifiers, and among the applications was a high-speed sampling oscilloscope exhibited by the Atomic Energy Research Establishment. The University of Birmingham showed experimental work on space-charge-limited currents in cadmium sulphide crystals. Associated Electrical Industries Research Laboratories showed some of the results of their investigation of etch-pits and other surface defects on germanium and silicon crystals, and of the diffusion of aluminium towards dislocations in silicon crystals.

This Convention was not intended as a continuation of the Reading–Amsterdam–Garmisch–Rochester series sponsored by the International Union of Pure and Applied Physics, but rather as one to bring together the specialists from among the makers and users of transistors. It had something in common with the germanium and silicon materials and devices sessions of last year's Brussels conference. It is, however, to be hoped that the organizers of future conferences on transistors and related devices will take note of the very real risks of devaluation of the meetings caused both by overloading and by dilution of the programme with material that is either not pertinent enough or novel enough to those (generally already more or less expert in the subject-matter) most likely to benefit from the discussions.

F. F. Roberts
H. G. Bassett

NEW MEDICAL-SURGICAL BUILDING OF THE ONTARIO VETERINARY COLLEGE

THE new medical-surgical building of the Ontario Veterinary College was opened recently by two ministers of the Province, the Minister of Agriculture, the Honourable W. A. Goodfellow, and the Minister of Public Works, the Honourable T. R. Connell. In Canada and the United States there is a division of responsibilities for certain service between the federal and the local government, and in both countries education is a local responsibility and provided by the Province or the State. The College was founded in Toronto as a private institute in 1862 by Andrew Smith, a graduate of the Royal Dick Veterinary College in Edinburgh, and was acquired by the Government of Ontario in 1908. It was affiliated to the University of Toronto at that time and was transferred to Guelph in 1922. The present dean, Dr. T. Lloyd Jones, a Welsh-born Canadian, was appointed in 1952. Dr. Jones has done a great deal to improve the teaching and research facilities of the College. He is interested in the broad field of veterinary education, has travelled in the United States, South America, India and Europe, to study this subject and has acted as a consultant on international problems in veterinary education.

The new buildings provide incomparable facilities for teaching clinical subjects ; the older accommodation has also been retained for housing animals for disease investigation, thus greatly increasing the available animal space. To provide a similar building in Britain would cost about one million pounds. Facilities for teaching the preclinical subjects are provided on the same generous scale, and it is proposed to re-house some of these departments in the next few years. Generally, the veterinary schools in North America are on a more lavish scale than those in Britain. At Guelph the new accommodation brings the college to a very high level even by American standards. There is only one other college in Canada, at St. Hyacinthe, Quebec, where instruction is given in French.

The College is affiliated to the University of Toronto, but its administration is vested largely in the dean and the Veterinary Faculty, with responsibility to the Ministry of Agriculture. Courses of study are submitted to the Senate of the University of Toronto. As a result of the growing demand for university education in Canada, the educational institutes at Guelph may, in the not too distant future, attain full university status. If this takes place it would be a reversal of the pattern so common in Britain where arts and humanities so often precede the science subjects. Guelph would be unique in having veterinary science as its oldest faculty, 1862, followed by agriculture twelve years later. This latter has developed into a very large faculty comprising large units for each of its component subjects. Guelph and Toronto are about sixty miles apart, but this distance has not prevented close collaboration between members of the medical and veterinary professions in a number of research subjects. For many years there has been a close liaison between the Department of Physiology of Toronto Medical School and the Surgery Department of the Veterinary College. In the more recent past a joint team of medical and veterinary workers has carried out an investigation on atherosclerosis and studied the effect of certain phospholipids in experimental work on pigs.

The new building is constructed in red rustic brick and modern building materials have been utilized in the floors, walls and ceilings, each suitably selected for function but designed in such a way that æsthetics and function combine to form a most attractive building. Those who planned the buildings studied the layout of a number of clinical departments. They were able to avoid the faults which experience had brought to light in several schools. There are several operating theatres equipped for large animals and a number of small animal theatres all serviced by central sterilization. The X-ray equipment is specially designed for large animals and has special Buckie screens for use with horses and cattle. A large therapy unit is also available. Housing has been provided for all types of animals, and the small animal unit is up to the standard of a modern hospital and is air-conditioned throughout.

In meeting the cost of this magnificent new building the Provincial Department of Agriculture has recognized the great contribution that can be made and has been made by the veterinary profession on an increasing scale to the economy of the country. This type of clinical department is particularly essential in veterinary schools where the teaching material cannot be provided in existing hospitals.

Eleventh Annual Convention of the Canadian Veterinary Medical Association

The Convention, held in the Ontario Veterinary College, was attended by more than six hundred veterinarians from Canada, the United States, Great Britain, South America and the Caribbean area. The visitors included practitioners, federal and provincial workers, and those interested in research, education and public health. Meetings were held in the new hall and in the Agricultural College buildings. In a presidential address, Dr. J. N. Henderson, professor of clinics, expressed the view that great changes were taking place in agriculture, that farming was no longer a way of life but was becoming a means of earning a living and that small units would have to merge to form a unit that would give a financial return comparable with other occupations. The veterinary profession would have to train graduates who were fully aware of economic factors in animal production and be able to provide an appropriate professional service.

There were papers on many aspects of modern surgical techniques in large and small animals and an up-to-date review of the application of radiology to veterinary practice. Fundamental aspects of bacteriology and virology were discussed, and papers dealt with the zoonoses with particular reference to government participation in schemes of control. The role of the profession in the civil defence programme was outlined. The structure of the poultry industry in North America has changed

radically during the past ten years and the role of the profession in these new circumstances was discussed. While there is a general acceptance that the medical and veterinary professions have a great deal in common in teaching and research, the main divergence arises at the point of application to their respective patients. Economic considerations are of greatest influence in the poultry industry, where a setback in rearing birds may represent the difference between a profit and a loss; there are similar considerations with all the farm animals and it is only with pet animals that sentiment replaces economic considerations. The diverse problems arising in controlling rabies were discussed and a film was shown of clinical cases of rabies in dogs, cats and cattle. In North America there is a reservoir of infection in wild life—foxes, wolves, skunks—and relatively few cases in dogs. In Trinidad there is a vastly different problem where vampire and other bats act as reservoirs and the epizootic pattern in cattle varies with the disease position in colonies of bats. These colonies break up and disperse when furious rabies develops and causes infection in cattle in new areas. In Great Britain dogs and cats entering the country are held in quarantine for six months and it is clear that this is a small price to pay for freedom from this disease. There were three British veterinarians present who contributed to the proceedings. J. N. Ritchie, chief veterinary officer of Great Britain, presented a paper which surveyed the present position of the veterinary services in Britain, and W. L. Weipers, of the University of Glasgow, reviewed developments in veterinary education. D. D. Lawson, of the University of Glasgow, presented a paper on thoracic surgery and gave a televised demonstration of volatile anæsthesia in the cow and the dog.

This Convention provides a forum for the discussion of scientific and administrative matters which affect the profession in Canada. As Guelph is the alma mater of the majority of veterinarians who live in Canada, the meeting in this city also took on the character of an alumnus reunion and the social functions were very well attended.

CONTROL OF GOVERNMENT RESEARCH AND DEVELOPMENT EXPENDITURE IN BRITAIN

THE seventh special report from the Select Committee on Estimates for the session 1958–59* contains the observations of the Treasury on the sixth report from the Select Committee for the session 1957–58 dealing with Treasury control of expenditure (see *Nature*, **182**, 1467; 1958). While the Treasury agrees with the Committee's general analysis and many of its comments on particular points, the Treasury suggests that in some respects the Committee's conclusions imply some misconceptions of what is needed, what is possible and what is in fact done. It is claimed that the theory of departmental responsibility and partnership has been steadily pursued under successive Governments for about forty years, and the Treasury does not agree that, while new expenditure may be carefully watched, continuing expenditure may escape relatively unchallenged. Although the main responsibility for vigilant watching for economy in continuing expenditure rests, and must rest, with the spending Department, the Treasury does in fact supplement the Department's own efforts by maintaining a constant watch on continuing expenditure, as well as by bringing particular areas of such expenditure under special review from time to time. A high proportion of the Treasury's time is in fact devoted to considering such continuing expenditure.

On the Committee's suggestion that eventual commitments are inadequately assessed, the Treasury points out that a wide degree of uncertainty must often remain as to the eventual cost of research policies or major developments involving the solution of scientific and technical research problems; the comment is made that it is unrealistic to suppose that some alteration of financial technique in the Treasury could avoid such difficulties. Secondly, the Treasury points out that forecasts of all civil expenditure, up to three years ahead, have in fact been prepared annually for many years past, and play a very important part in the general control of Government expenditure. Without claiming that the technique of 'forward looks' is yet as fully developed or effectively exploited as it might be, the Treasury points out that Ministers are able to decide how far it is necessary to review existing policies reflected in the forecasts, and to adjust new policies which they may have had in mind, to contain the total of Government expenditure within acceptable limits. In devoting further attention to this matter, the Treasury undertakes, however, to have full regard to the Committee's comments. Again, while the Treasury agrees generally with the Committee as to the importance of prior sanction control, and also that the limits of delegated authority should be periodically reviewed as is at present done, it does not interpret the Committee's report as recommending in general any major change in the existing policy. It agrees with the Committee's view that delegation so far as is compatible with the reservation to the Chancellor of the Exchequer of the power to discharge effectively his own essential responsibilities is primarily an attitude of mind which should lead to action whenever opportunity offers; but the three criteria suggested by the Select Committee in this connexion are regarded neither as a complete guide nor, within the ground they cover, as a wholly reliable one.

The Select Committee on Estimates had recommended specifically that a small independent committee, which should have access to Cabinet papers, should be appointed to report upon the theory and practice of Treasury control of expenditure. This recommendation the Treasury does not accept, and the report sets forth at some length the reasons why the Government is not prepared to accept the recommendation; although in view of the Committee's

* Seventh Special Report from the Select Committee on Estimates, Session 1958–59. Treasury Control of Expenditure (Observations of the Treasury). Pp. 16. (London: H.M. Stationery Office, 1959.) 1*s.* net.

observations, the Government is initiating an internal inquiry, to be conducted under the general authority of the Chancellor of the Exchequer, into the principles and practice which govern the control by the executive of public expenditure. The conclusions reached by the Government will be reported to Parliament in due course.

The Treasury recognizes that the operation of Treasury control should be under constant review, but it does not consider that a review by an outside committee would be useful, partly because it would involve, in effect, a review of the Chancellor's conception of his own responsibilities, and partly because it would probably be found that a review of this kind would need to be extended beyond the Treasury itself into Parliamentary practice and into the financial control exercised by each major Department of State. The Treasury submits that it would be inappropriate for the Government to seek recommendations on Parliamentary practice from a body independent of Parliament, and that a realistic appraisal of the Government's financial control involves also consideration of the working of the central processes of government. It would also be inappropriate, the Treasury believes, for an independent committee to scrutinize and pronounce on the inner counsels of Government or on the resulting decisions, for which the Government is responsible to Parliament alone.

Some reservations may be entertained on these points; but so far as the scientist or technologist is concerned, comment may well be left until the committee inquiring into the methods of managing and controlling research and development projects, of which Sir Solly Zuckerman has now succeeded the late Sir Claud Gibb as chairman, reports in due course. It should suffice to note meanwhile that the Treasury is very conscious of the need for strengthening and developing, on the right lines, the control, whether by the Treasury or by Departments, of expenditure on research and development, and is in broad agreement with the Committee's observations on these matters. Discussions of which the subcommittee was informed in evidence have already resulted in agreed arrangements, which it is hoped will prove satisfactory in practice, for the closer association of the Treasury with work on defence research and development programmes.

THE U.S. NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL, 1957–58

THE report of the U.S. National Academy of Sciences—National Research Council for 1957–58 (Washington, D.C.: National Academy of Sciences—National Research Council, 1959), published with the President's review and the report of the Treasurer, covers briefly the work during the year of the eight divisions of the Council, of the United States National Committee for the International Geophysical Year, and of the Office of International Relations and the Office of Scientific Personnel. The president, Dr. D. W. Bronk, points out that the operating budget of the Academy is now about 10·6 million dollars, an increase of 3·5 millions on 1956–57, and two-thirds of its direct expenditure came from federal agencies. A major undertaking (at the request of the Air Research and Development Command) of the year was a study of the scientific and technological future of the Air Force, while the Council's Highway Research Board is now responsible for conducting the American Association of State Highway Officials Road Test at a cost of more than 20 million dollars. The Committee on Meteorology, formed two years ago, has completed its study of how meteorology could be furthered, with reference to the needs of the Weather Bureau, and has proposed the establishment of a National Institute of Atmospheric Research. During the year a Committee on Oceanography was organized and the Division of Mathematics, with the assistance of the National Science Foundation, completed its survey of research potential and training in the mathematical sciences. At the request of the Secretary of Commerce the Academy is organizing a committee to evaluate the functions and operations of the Department in relation to national needs, with especial reference to the National Bureau of Standards, the Weather Bureau, Patent Office and Office of Technical Services.

Among miscellaneous activities of the Council not assigned to a division, the report notes those of the Advisory Board on Education, which has given special attention to improving the education of teachers and to studies of science curricula and courses, the committees concerned with the study of the biological effects of atomic radiation, the establishment in February 1958 of a Committee on Polar Research and the work of the Space Science Board, which held its first meeting in June 1958, and is studying the opportunities for scientific research opened up by the advent of modern satellites and rocket tools and their needs.

To a certain extent, some of the activities described in this report, such as those of the United States National Committee for the International Geophysical Year and the Office of Scientific Personnel, are covered by the annual report of the National Science Foundation, from which they received financial support and need not here be further described. Of those of the Research Council's own eight divisions a few examples are selected for illustration. The Division of Anthropology and Psychology participated in some cross-disciplinary projects including a contract with the Air Force for a study of problems connected with bio-astronautics, under the supervision of the Division of Medical Sciences, and a conference on Psychological Research in Education. It is also administratively responsible for the Armed Forces–National Research Council Committee on Vision. The Division of Biology and Agriculture reports no new major projects. The Division of Chemistry and Chemical Technology at its annual meeting was concerned with international chemical affairs and the improvement of documentation in chemical literature but reports no outstanding activities of its units.

The Division of Earth Sciences rendered advisory services to the Federal Government through its

committees and also conducted the Arctic Sea Ice Conference in February 1958 at the request of the Government. The Division of Engineering and Industrial Research provided advisory services over a wide field of increasing importance and complexities, including such matters as electrical insulation, fire research, highway research, building research, prosthetics research. The Division of Mathematics appointed two new committees, one on statistics and the other to report both to the Division and to the Advisory Board on Education, on mathematical films and television. The Division of Medical Sciences initiated a new project in medical genetics, which will establish a large roster of veteran twins, diagnosed as to zygosity, as well as other studies of rheumatoid arthritis, lesions of the lumbar disk and Japanese *B* encephalitis. The interest of the Sub-committee on Trauma continued to centre on the treatment of burns, particularly those involving the respiratory tract. The Division also participated in the establishment of the Inter-departmental Committee on Blood Programme Research and through its Committee on Sanitary Engineering and Environment the Division is increasingly concerned with toxicological hazards arising from the rapid introduction of many new types of material into industry and into the home. The Committee on Tissue Transplantation sponsored a symposium on serological immaturity and agammaglobulinæmia and non-specific forms of lowered resistance to transplanted tissues, including the effects of radiation and cortisone. A primary aim of a revised programme of the Committee for Research into the Problems of Sex is the encouragement of young investigators interested in careers in the field of behavioural research.

The Division of Physical Sciences reports a balance between activities in response to requests from the scientific community and in response to Government requests and between those in physical science and in applied science. Its Committee on Nuclear Science continued to be the largest and most active. Its services to the Government included those of the Committee on Undersea Warfare and the Mine Advisory Committee, and the critical review of Air Force research and development planning noted above and a review of the activities of the National Bureau of Standards.

CLERICAL SALARIES IN BRITAIN

THE eighth of the Office Management Association's surveys of clerical salaries embraced a sample of almost ninety thousand clerks*. For the most part, these were employed in private commercial, industrial and professional offices. In addition, one part of the survey related to clerks employed in the public service, nationalized industries, and the joint stock banks. In one form or the other, therefore, the survey supplied information about the salaries of clerks in all parts of the British economy.

Women clerks formed 64 per cent of the clerks in the sample. This compares with the 67 per cent of women among the clerks employed in the corresponding industries in 1951 when the last census of population was taken.

The clerks were employed in a wide variety of British industries but some industries were better represented in the sample than others: ceramics, glass and cement, etc.; chemicals and allied trades; metal manufacture; engineering, shipbuilding, and electrical goods; textiles; food, drink and tobacco; other manufacturing industries were well represented by samples amounting to 10 per cent or more of the clerks employed in industry. The very large number of clerks employed in vehicle manufacture, distributive trades, and in professional and miscellaneous services, were represented by samples of less than 5 per cent. There had been no change since earlier surveys in the proportion of clerks employed on work of this kind. For the men this proportion was only 60 per cent; but 83 per cent of the women were in routine jobs.

On the whole, male clerks' salaries have risen between 12 and 16 per cent in the past two years and those of women clerks between 11 and 13 per cent. The exceptions to this pattern are male clerks doing the lowest grades of routine jobs, whose salaries have risen by between 16 and 27 per cent, and the women doing the lowest grade of routine jobs, whose salaries have risen by 14 per cent (clerks under twenty years) and 17 per cent (clerks over twenty years). As the index number of retail prices has risen by 7 per cent during the same period, the real salaries of the clerks have gone up between nearly 5–9 per cent for men and 4–6 per cent for women. Superimposed on this general increase is a large rise for clerks doing the lowest routine jobs.

Manual workers' wage rates during the period from February 28, 1956, to the same date in 1958 rose by just over 11 per cent. Clerical salaries, therefore, rose as much as, or more than, the wage rates of manual workers during the past two years. Wage rates do not, however, tell the whole story concerning manual workers' share of the national economic cake; the fluctuations in their earnings may differ quite considerably from the fluctuations in wage rates. No similar complication affects clerical salaries to anything like the same extent.

It appears, nevertheless, that clerks have in this period done rather better than manual workers in the continuous process of redistributing income. This comes after a decade in which male clerks have been losing ground to manual workers.

Increases have been proportionately less for clerks engaged on more senior and responsible work. Many have scarcely had any increase in salaries at all over and above that accounted for by the fall in the value of money. Because the salary increases during the past two years have been proportionately slightly less for women than for men, the gap between the salaries of men and women clerks doing similar work has widened a little since 1956.

The United Kingdom does not form a single market for clerical labour and even nation-wide employers of clerks recognize this, at least to the extent of introducing London allowances into their national scale. These scales and allowances may be administratively convenient, but the pattern of local clerical markets is more complex than the simple one of a London market and a provincial market assumed by

* Clerical Salaries Analysis, 1958. (Office Management Association, 58 Victoria Street, London, S.W.1.) 42*s*.

most national employers. The areas of the highest salaries were mainly those having the prosperous engineering, shipbuilding, food-processing and chemical industries in good measure with a high proportion of export trade. It is reasonable to assume that the pattern of clerical salaries for adult male clerks followed a pattern of economic prosperity.

London comes fairly low down on the scale. Within Greater London there was only one district—the West End—where salaries were comparable with those on Merseyside. This is in contrast with the usual assumption that salaries are generally higher in London than in the rest of the country.

The pattern of variations of salaries for women clerks is simpler and more in accordance with traditional ideas. Greater London was the area of high salaries; the other conurbations had noticeably lower salaries with little to choose between them in contrast with the experience of men clerks in this area.

HELP FOR THE ARTS

ALTHOUGH the full policy of the Calouste Gulbenkian Foundation of Lisbon includes the fields of science, art, education and charity, it now announces that it is prepared to implement the suggestions in a report just issued*. This means that for the next three or four years the emphasis of the activities of the Foundation in the United Kingdom will be almost exclusively in the field of the arts.

The report, prepared by a small informal committee consisting of Lord Bridges (chairman), the Countess of Albemarle, Mr. Nöel Annan and Sir George Barnes, is the result of their deliberations to help the Foundation by a review of the needs of the arts in Britain. After a few discussions in London the committee visited Bristol, Cardiff, Glasgow, Liverpool, Newcastle upon Tyne and Nottingham. Information was also supplied by a hundred local authorities and by all the universities.

Probably the most striking and indeed definite conclusion is that the arts need help in the provinces to a far greater extent than they do in London. Another point is that far greater support is needed for the arts than in the past and also that this is not a temporary need. This means that in the future public authorities will have to find more money for the arts. It is also stressed that far more needs to be done to-day to render the arts accessible, that there should be more scope for experiment in order to invigorate the arts and that more should be done to foster appreciation among the young. If, as the committee believes, the Foundation can do its best service by stimulating art in the provinces it is pointed out that although under the Local Government Act of 1948 local authorities are permitted to spend up to a 6*d*. rate each year on any form of entertainment it is ascertained that over the whole country expenditure does not exceed $\frac{3}{4}d$. rate for museums and art galleries and $\frac{1}{5}d$. for music and drama. The members of this informal committee consider that the universities could and should do much more for the 'practice' and encouragement of the arts. Traditionally, this has been left to university societies and thus is outside the scope of the university patronage.

In discussing the specific ways in which the Foundation can help, it is stressed that it should be prepared to back individuals—and to encourage and foster new developments or growing points, feeling that eventually they will be self-supporting and attract permanent support from public funds or elsewhere.

Museums and art galleries receive much consideration, and although the committee welcomes the increase in grants recently announced it is suggested that pictures accepted by the Treasury in lieu of death duties should in certain cases pass to the provincial galleries. This involves the acceptance of pictures perhaps not of exceptional importance but of great interest to a local gallery. It is also felt that although museums have done much good work in developing school services they seem to have lagged behind the expansion in other educational fields. A more active policy of loans between museums is advocated, and for this a general survey of material in the collections is essential. This also leads to the establishment of an improved conservation service. It is also suggested that the Foundation might help to buy works of art for provincial galleries.

In conclusion, the committee considers that Great Britain is producing artists of the highest quality, but adequate support or patronage is lacking. It is to be hoped that the Foundation gives a speedy implementation to the suggestions in this report and then in good time turns to the support of the sciences in Great Britain.

* Help for the Arts: a Report to the Calouste Gulbenkian Foundation. Pp. 64. (London: Calouste Gulbenkian Foundation, United Kingdom and British Commonwealth Branch, 1959.) 3*s*.

DIETARY FACTORS IN THE HOMOGRAFT REACTION

By Dr. A. S. PARKES, F.R.S.

Division of Experimental Biology, National Institute for Medical Research, Mill Hill, London, N.W.7

EXPERIMENTS carried out in 1955 with five strains of mice maintained at this Institute showed that ovarian autografts established themselves regularly and became endocrinologically active within an average time of 10–11 days. In three of the strains intra-strain homografts behaved similarly during the four-week period of observation. In the other two strains, intra-strain ovarian homografts took and survived less well than autografts. Inter-strain ovarian grafts took moderately in some combinations, but rarely survived for four weeks[1].

Repetition of some of these experiments two years later showed that there had been a marked increase in resistance to intra-strain grafts. In the three

strains re-investigated (*TO*, *PA* and *WT*) 25/27 of such grafts had taken in 1955, and 19 had survived in a functional state for four weeks, whereas in 1957, 15/29 took and 7/29 survived the test period. Various other experiments with gonad grafts in mice and rats made at the Institute about this time also suggested that there had been an increase in homograft reaction.

Review of the animal husbandry showed only one factor of likely significance: the staple cubed diet (diet 41) had been modified by the substitution of vitamin concentrate and molasses for cod liver oil (diet 41*B*)[2], and an investigation was therefore started to find out whether such a change could have affected the homograft reaction.

The technique was as described previously[1]. Young adult females were spayed, the ovarian capsule, the Fallopian tube and the top of the uterus all being removed to minimize the possibility of ovarian regeneration. The ovaries from donor animals were dissected free of adnexa, cut into two pieces and implanted under the skin of the flank. The establishment of an active graft and its survival time were determined by the re-occurrence of cornified cells in the vaginal smear.

The first experiment was to make a new batch of diet 41, so that a direct comparison could be made between mice maintained on it and on diet 41*B*. For this purpose, *PDE* mice, a sub-strain of *PA* mice, were used; these were known to show a vigorous intra-strain homograft reaction (10/30 grafts established and 3/30 surviving 4 weeks). *PDE* breeding mice were maintained on diet 41 for some months and then the intra-colony homograft reaction in 40 females drawn from this colony was compared with that in 40 females of the same strain maintained on diet 41*B*. The results are shown in Table 1.

Table 1. The Intra-strain Homograft in Colonies of *PDE* Mice maintained on Diet 41 and on Diet 41*B*

Diet	No. of females receiving implants	No. of females developing active grafts	No. of females with active grafts at 28 days
41	40	28	13
41*B*	40	13	4

The difference in the number of mice developing active grafts was significant at the $P = 0{\cdot}01$ level and substantiated the idea that the change in homograft reaction between 1955 and 1957 had been associated with the change of diet. The results of a small series of inter-colony grafts were concordant with the presumption that the difference in homograft reaction originated in the recipient rather than in the tissue grafted.

Attention was then turned to the nature of the dietary factor involved in modifying the homograft reaction. Diet 41 had been abandoned because of the destructive action of the cod liver oil on the vitamin E. It was thought, therefore, that treatment of 41*B* with excess of cod liver oil might abolish its effect in augmenting the homograft reaction. Results with 20 mice, however, gave no support to this idea; but the result cannot be regarded as conclusive, because the unpalatability of the treated diet 41*B* prevented an adequate preparation period.

At this stage, my colleague Dr. J. H. Humphrey directed my attention to the work of Axelrod and others, who had investigated the effect of various dietary factors on immunological response and who had found that pyridoxine-deficiency, whether induced by deficient diets or pyridoxine antagonists, notably depressed antibody formation[3,4].

On the basis of these reports plans were made to test the homograft reaction in pyridoxine-deficient animals. In a first experiment, 10 *PDE* mice maintained on diet 41*B* were injected daily with 0·25 ml. saline and a similar group with 0·25 ml. saline containing 2·5 mgm. deoxypyridoxine. After four weeks, intra-group ovarian homografts were made, treatment being continued. After another four weeks, 5 of the 9 surviving antagonist-treated animals retained active grafts, but only one of the 10 control mice. This result, although not itself of great statistical significance, was distinctly encouraging and more extensive experiments were carried out on mice receiving homografts after preparatory treatment for four weeks with deoxypyridoxine added to the drinking water in amounts calculated to give an intake of 2·5 mgm. or 5·0 mgm. per day. Results are summarized in Table 2, and indicate that the oral administration of deoxypyridoxine to the recipient markedly increased the survival-rate of ovarian homografts. 5 mgm. daily was not detectably more effective than 2·5 mgm., and was appreciably more toxic in that 7/30 of the animals died during the experiment. The effect on the survival of homografts was abolished by the administration of pyridoxine during the second half of the preparatory period and was therefore due to pyridoxine-deficiency rather than to some side-effect of the antagonist. When re-examined after 3 months, 10/36 of the mice treated with deoxypyridoxine only retained active grafts compared with 0/37 in those receiving deoxypyridoxine plus pyridoxine.

Table 2. Takes and Survival of Intra-strain Homografts in *PDE* Mice maintained on Diet 41*B* with and without Deoxypyridoxine

Preparatory treatment for 4 weeks	Proportion of animals developing active grafts	Proportion of animals with active grafts at 28 days
None	10/30	5/30
2·5 mgm. per day deoxypyridoxine	17/20	12/20
5·0 mgm. per day deoxypyridoxine	19/23	14/23
2·5 mgm. per day deoxypyridoxine	26/38	17/38
2·5 mgm. per day deoxypyridoxine + 1 mgm. pyridoxine per day for last 2 weeks	13/38	2/38

Experiments were then extended to inter-strain homografts, *TO* females receiving ovarian implants from *PA* females. The results are shown in Table 3.

Pyridoxine deficiency is therefore almost as effective in preserving inter-strain as intra-strain homografts, and as with the intra-strain grafts, the higher dose did not appear to be more effective. Re-examination of four groups of the treated animals at the end of three months showed that 9/30 retained active grafts.

Table 3. Takes and Survival of Inter-strain Homografts in Recipients with and without Deoxypyridoxine

Preparatory treatment for 4 weeks	Proportion of animals developing active grafts	Proportion of animals with active grafts at 28 days
None	4/20	0/20
2·5 mgm. deoxypyridoxine per day	18/28	12/28
5·0 mgm. deoxypyridoxine per day	9/15	5/15

Table 4. SURVIVAL OF RAT OVARIAN TISSUE GRAFTED INTO PYRIDOXINE-DEFICIENT MICE

Preparatory treatment for 4 weeks	Strain of mouse	Proportion of animals developing active grafts	Proportion of animals with active grafts at 28 days
None	*PA*	11/40	0/40
2·5 mgm. deoxypyridoxine per day	*PA*	10/37	6/37
None	*PDE*	9/19	0/19
2·5 mgm. deoxypridoxine per day	*PDE*	28/40	12/40

Striking results were obtained with heterografts of rat ovaries made into treated mice (Table 4).

In the third group of mice the surviving grafts were removed by operation after five weeks and were found to be relatively very large and, although heavily infiltrated with leucocytes, were found on histological examination to possess numerous follicles and corpora lutea. In general, these heterografts were very different from the few small degenerate specimens which can be found in untreated mice at five weeks after the subcutaneous implantation of rat ovarian tissue.

The effect of pyridoxine deficiency in depressing the reaction against ovarian homografts is greater than that of a single dose of whole-body irradiation in mice[5] and of the same order as that which can be obtained in rats by pre-conditioning the prospective recipient with suspensions of homologous tissue[6]. It is less permanent according to present experience than the effect which can be obtained by the induction of tolerance early in life[7].

While these experiments were in progress, Axelrod and his collaborators[8], in continuation of their earlier work, published the results of experiments on intra-strain skin grafting in pyridoxine-deficient rats. In two strains of rats they found that the percentage of takes in deficient rats was far higher than in normal ones, and in one strain survival at 10 weeks was also far better. Experiments on man, however, failed to give analogous results, possibly because the degree of pyridoxine-deficiency was inadequate[9].

So far as rats and mice are concerned, however, it seems clear that the reaction against skin and ovarian homografts respectively is much reduced by pyridoxine deficiency. According to Axelrod *et al.*[8], "it is possible that this effect is related to an inhibition of the immune response to the antigens of the donor skin in this deficiency state". With this suggestion, it seems desirable to postpone discussion until more facts are available.

My thanks are due to Dr. J. H. Humphrey, Dr. H. R. V. Arnstein and Miss H. M. Bruce for advice, and to Miss M. P. G. Moylan and Miss B. M. Flannelly for technical assistance.

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DIAPHRAGMS FOR ANALYSING THE DEVELOPMENT OF CONNECTIVE TISSUE

By PROF. HANS SELYE
Institut de Médecine et de Chirurgie expérimentales, Université de Montréal

TO gain fundamental information about the nature of any complex biological structure or process, we have to develop techniques which permit us to analyse it by breaking it down into its constituent elementary units; the dissection of organs, the preparation of pure microbial or tissue cultures are examples in point. The study of the laws that govern the developmental mechanics of connective tissue (for example, during normal growth, wound healing and inflammation) has been greatly handicapped by the lack of techniques suitable for an analysis of this kind. Normally, the cells and intercellular structures of connective tissue form an extremely complex maze. Even the simplest linear wound elicits a multitude of interdependent regenerative processes the elements of which (exudate, fibrin, fibres, cells, vessels) interlace in all directions, so that a study even remotely resembling an 'elementary analysis' of the constituents becomes virtually impossible. Accordingly, the scope of the conventional techniques for the study of connective tissue is necessarily limited to the description of histological or chemical components, the uptake of vital dyes, the speed of cicatrization, the measurement of tensile strength, etc.

The object of this communication is to describe the design of diaphragms which, when introduced into connective tissue, present it with simple problems of organization, in that they block growth except along one, or more, regular, predetermined channels. Thus we can obtain single beams of connective tissue, or cords intersecting at any desired angle; these, like the parallel beams of light produced by optical diaphragms, lend themselves to reveal the underlying order in an otherwise confusing complexity.

All experiments were performed on female Sprague–Dawley rats, with an initial body-weight of 100–150 gm. The sterilized diaphragms were introduced beneath the shaved dorsal skin, under ether anæsthesia. Groups of rats were then killed at weekly intervals, to examine the progress of organization macro- and microscopically.

Analyser diaphragms may be prepared of various materials (plastics, china, rubber, paraffin-coated paper, etc.), but glass is the most satisfactory: it can easily be shaped, chemically cleaned and sterilized, its hard, smooth surface prevents adhesion of tissue to the wall, and its transparency facilitates examination of the contents.

Fig. 1 illustrates a few of the basic patterns of tissue-diaphragms that were employed for analysis.

The simple tube, open at both ends (Fig. 1*A*, *B*, *C*), permits only unidirectional growth, in the form of a

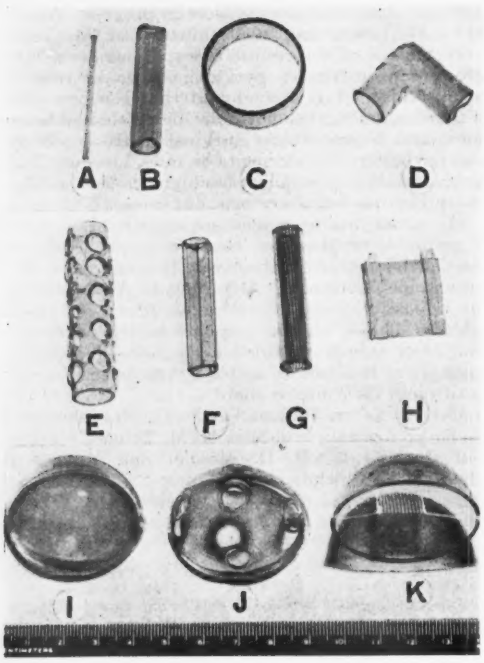

Fig. 1. Samples of various tissue diaphragms

connective-tissue cord that connects the two orifices. The length and calibre of the tube vary in accordance with the problems to be studied; capillaries and small-bore tubes have the additional advantage of being readily implantable, not only into loose connective tissue, but also into muscles, pleura, peritoneum and various parenchymatous organs. Tubes with one end closed revealed that a minimum of two 'tissue bridgeheads' is necessary for rapid organization of a gap, while L-shaped (Fig. 1*D*) and branching tubes (in the form of a Y, T or +) are employed to examine the formation of anastomosing tissue cords at predetermined angles. One perforation or more in the wall of the tube (Fig. 1*E*) offers additional possibilities for the establishment of tissue connexions within a single cylinder (that is, unguided by restraining individual tubular walls around each tissue-cord). Simple, straight tubes, open at both ends, containing a central nylon thread (Fig. 1*F*), an inner parietal lining of fine nylon trellis (Fig. 1*G*), or a central flat 'ladder' of nylon trellis that connects the two open ends revealed that this additional internal scaffolding is especially effective in accelerating organization along the threads. Organization is also expedited by enveloping the diaphragms in nylon trellis; the rapid invasion of the latter by connective tissue furnishes a stabilizing capsule for the whole object. Double plates (two coverglasses, their surfaces slightly separated by lateral glass ledges) offer the possibility of studying two-dimensional invasion of a flat space (Fig. 1*H*); the tissue formed in this can then be examined by merely placing the entire object under the microscope. Hemispheres, or—because of the shape of the rat's back—hemi-ellipsoids are used to examine factors which influence the three-dimensional organization of rounded cavities. These structures offer no entry to tissue, except at their base (Fig. 1*I*), or have one additional opening or more on the roof (Fig. 1*J*) for the exploration of simple or complex tissue-bridge formation. Finally, minute perforations in the roof (which can afterwards be sealed with a drop of paraffin) make it possible to attach threads or trellises of nylon at any point of the roof, thus connecting it with the base (Fig. 1*K*). It is then possible to explore the effectiveness of the nylon scaffolds as tissue guides.

Fig. 2 shows a hemispherical analysing diaphragm with multiple perforations, under the shaved dorsal skin of a rat, two weeks after implantation. The scar of the incision, through which the object had been introduced (dark spots near the root of the tail), is almost healed; it did not interfere with organization within the diaphragm, because the latter was pushed forward at some distance from the wound to prevent the development of external adhesions and diminish the probability of infection. Owing to the absorption of air from the cavity of the hemisphere, the skin over the perforations is slightly depressed. The depth of these depressions remains limited, however, because, soon after implantation, exudation begins and a characteristic, citrine, thick fluid fills out the empty space. This fluid does not coagulate *in situ*, but has some tendency to do so after evacuation. Eventually, fibrin threads, covered and invaded by histiocytes, connect the parietal openings with the base and thus provide temporary bridges. These are later organized by connective tissue and invaded by blood vessels.

This organization is most clearly illustrated by the simple, unidirectional growth that occurs in straight glass tubes (Fig. 3).

Two weeks after implantation of such a tube (3 cm. long, 0·8 mm. wide, and enveloped in a nylon trellis for better fixation), a straight axial cord has developed between the two openings (Fig. 3*A*). This cord consists of a broad, central spindle made up of fibrin threads and histiocytes. It is attached to the centre of the end-plates by a narrow filament of connective tissue, Van Gieson-positive and well vascularized. By this time, such tubes are completely or almost completely filled with citrine fluid

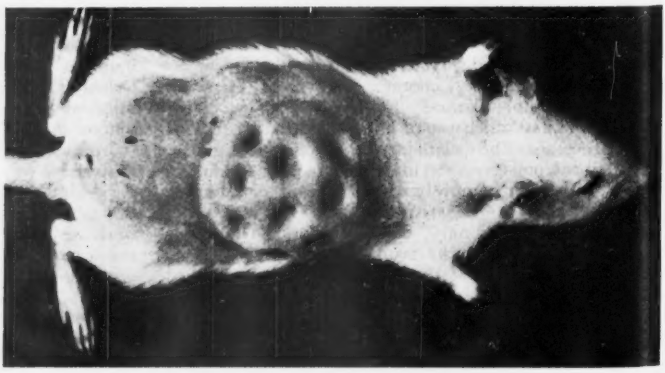

Fig. 2. Hemispherical tissue diaphragm as it appears *in situ*

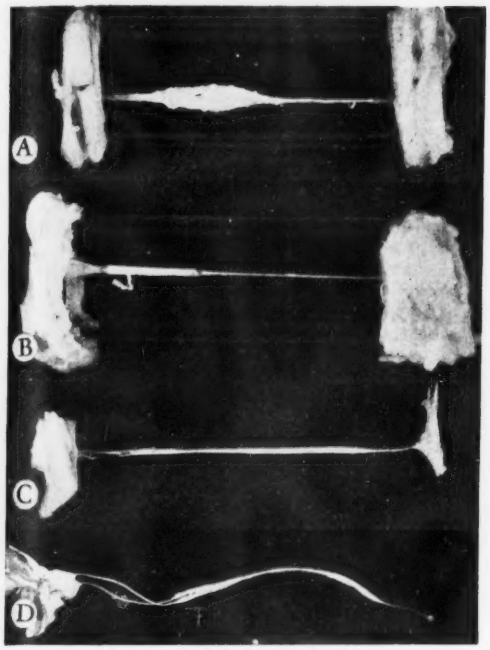

Fig. 3. Various stages and types of axial-cord formation within simple glass tubes. In *A* and *B* the tube and the disk-like connective-tissue plates at the opening are intact; in *C* and *D* the contents are represented after removal from the tube

and, although the two end-plates of connective tissue are broad, the bridge is invariably narrow and attached centrally.

After one month, the fibrin spindle becomes narrower and shorter (Fig. 3*B*); the 'growth line' that separates the light fibrinous centre from the darker invading tissue is reddish in the living animal. Quite commonly, invasion by connective tissue progresses much more rapidly on one side (in Fig. 3*B* on the right) than on the other, but the development of fibrin threads between the spindle and the glass wall (which apparently occurred here because of a rough dirt speck on the wall) is exceptional. It is also quite uncommon to find an accessory, abortive, second cord, attached unilaterally (Fig. 3*C*), or a complete Y-shaped, split cord, in simple straight tubes (Fig. 3*D*). Curiously, within the limits which have been studied so far, the speed with which the two openings are connected by an axial cord, and the thickness of these bridges, are largely independent of the length and width of the glass tubes.

The details of these investigations will be described elsewhere. Here, attention is directed merely to the possibility of analysing the mechanics of tissue growth by the selective restriction of proliferation to certain channels. It is hoped that such analysing diaphragms may prove useful in the study of developmental mechanisms under normal conditions and after the topical or systemic application of growth-modifying stimuli.

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ESTABLISHMENT OF PARENCHYMATOUS SPLENO-PULMONARY VENOUS ANASTOMOSIS

By Drs. GEORGE R. WALKER, PAUL FIELD and PATRICK E. CONEN

Research Institute, Hospital for Sick Children, Toronto

A SUCCESSFUL shunt between the splenic vein and the pulmonary venous system via a parenchymatous anastomosis in the dog has been achieved. The investigation was conducted in an attempt to find a solution to the problem of extrahepatic obstruction of the portal venous system in young children. At present, this condition in children is not as amenable to successful treatment by current methods of shunt operation as in adults. Further work will be necessary before application of this experimental work to clinical problems can be undertaken.

Dogs 8–20 kgm. in weight were used. General anæsthesia was induced and continued with thiopentone and succinylcholine chloride in divided doses, respiration being maintained by manual control of flow of oxygen through an endotracheal tube. Tetracycline was administered by mouth for ten days, beginning the day before operation, to avoid the high incidence of acute empyema which occurred post-operatively in the early attempts.

A thoraco-abdominal incision was made in the line of the eighth rib on the left side, and the spleen delivered through the wound. A bulldog clamp was temporarily applied to the splenic pedicle. Most of the spleen was removed, leaving part of the lower pole, measuring approximately $3 \times 2 \times 1$ cm. at the site of entry of the main lower division of the splenic vessels. The splenic capsule was removed except that on the hilar surface.

Next, a Satinsky vascular clamp was placed across the lower part of the lower lobe of the left lung, to act both as a retractor and as a hæmostat. An incision about 3 cm. long was made in the lung on either the costal or diaphragmatic surface, and continued deep into its substance. After bringing the splenic pedicle up through the tendinous part of the diaphragm, the remnant of the spleen was inserted into the opening in the lung and the lung sewn over it.

All clamps were removed and an intercostal drain inserted and connected to an underwater seal. The wound was closed in layers.

The operation is relatively easy to perform, and the procedure is usually completed in 1–2 hr. The overall operative and post-operative mortality was

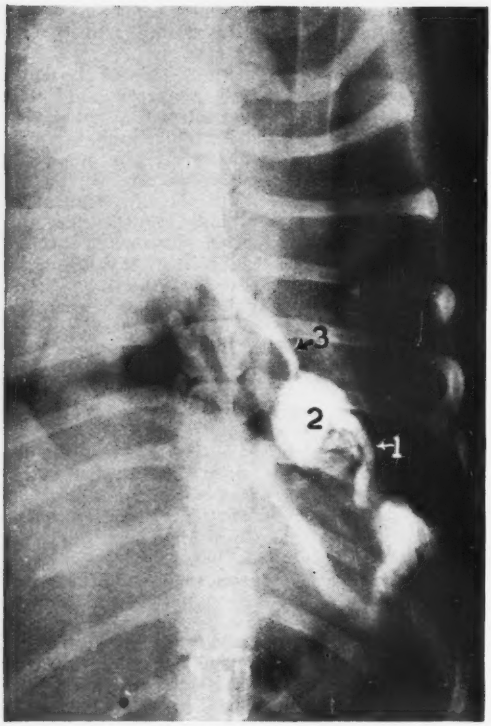

Fig. 1. Venogram showing anastomosis during injection of 'Hypaque —R'. 1, Splenic vein; 2, spleen; 3, inferior pulmonary vein

approximately 10 per cent. In the majority of cases, the dogs made rapid recovery and resumed normal activity and appetite within one or two days.

Demonstration of the Anastomosis

Each dog was explored through the original incision 8–10 weeks following the procedure, and the area of anastomosis was examined. It was noted at operation that good pulsation was present in the splenic artery. Most of the left lung was expanding normally, and only a small part of the lower lobe, approximately equivalent to one broncho-pulmonary segment, was firm and thickened.

Demonstration of the anastomosis was made by the following three methods:

(1) *Venography.* The splenic artery and vein were ligated and cut inside the abdomen and a polyethylene catheter was tied into the lienal side of the cut splenic vein. A roentgenogram of the lung was taken during injection of 10 ml. of 50 per cent 'Hypaque' solution.

Fig. 1 illustrates the typical appearance of the roentgenograms in the cases investigated in this way. The dye passed through the splenic vein in a retrograde direction into the implanted spleen and thence via the parenchymatous anastomosis into one of the left pulmonary veins.

(2) *Plastic Preparation.* After excision of the anastomotic area, polyethylene catheters were tied into the left inferior pulmonary vein and into the splenic vein. Simultaneously, liquid neoprene plastic was injected into both catheters at a pressure of 100 mm. mercury, a dark colour into the pulmonary vein and a light colour into the splenic vein. The catheter in the pulmonary vein was removed before that in the splenic vein. The specimen was then

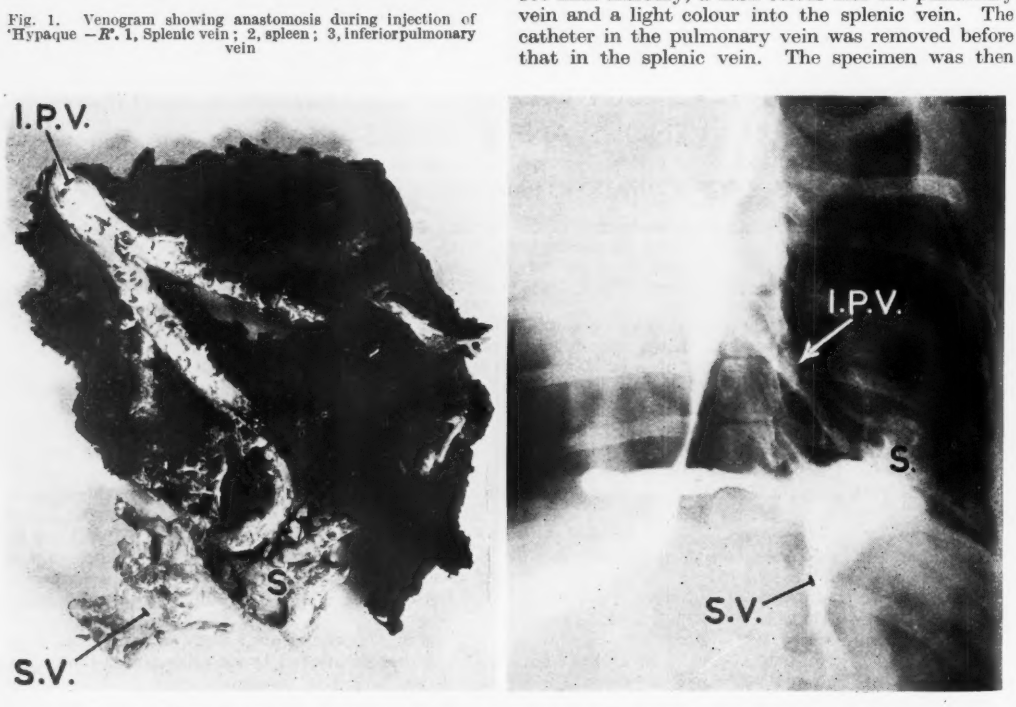

Fig. 2. Plastic cast showing filling of spleen and inferior pulmonary vein following injection into splenic vein. The venogram of the same animal taken during life is also shown for comparison (right). *S.V.*, splenic vein; *S*, spleen embedded in lung; *I.P.V.*, inferior pulmonary vein

Fig. 3. Low-power view (× c. 6·7) showing the embedded spleen (*S*) and the remnant splenic capsule (*C*) completely surrounded by lung (*L*). (Verhoeff's elastic tissue stain)

immersed in an acid bath which digested the soft tissue and left the solidified neoprene.

Fig. 2 shows filling of the splenic vein, the splenic remnant and the left inferior pulmonary vein with light-coloured plastic. This is in contrast to the dark-coloured neoprene in the small vessels of the lung parenchyma. Fine dissection of the plastic cast showed both colours in all the small vessels of the substance of the lung close to the embedded spleen.

(3) *Histology.* A specimen of lung containing embedded spleen was cut into thin slices and fixed in formalin. Blocks were sectioned serially and stained both by hæmotoxylin and eosin, and also by Verhoeff's elastic tissue and Van Gieson stain.

Fig. 3 shows a cross-section of the embedded spleen in the lung. A small portion of the intact splenic capsule remains while the rest of the spleen merges with the surrounding lung parenchyma. There is increased vascularity in the spleen and a dilatation of the pulmonary vessels surrounding the spleen. Large numbers of vessels are observed just outside the spleen, and dilated vessels are also present in the substance of the spleen (Fig. 4). In some areas a direct connexion between the pulmonary and splenic vessels was demonstrated by serial sections, although no indication of the direction of flow of the blood in the living animal was obtained.

Results and Discussion

In eighteen normal dogs, the spleen was embedded in the lung. Nine of these were examined by methods described above, and in all these evidence was found which was consistent with the establishment of vascular connexions between the two tissues. Of the remainder, five dogs are alive and well, two were operative deaths, and two died of distemper.

In this series of normal dogs a parenchymatous anastomosis between the spleen and the lung has been achieved. The difficulties of producing more than transient portal hypertension in dogs have long been realized, and have been described by Morris[1] as well as others. It was felt that for purposes of this initial study, the existence of portal hypertension in the experimental preparation was not obligatory since if good anastomosis could be obtained in an otherwise normal dog, an even better anastomosis could be anticipated in the presence of portal hypertension.

Further work is being conducted in order to discover the capacity of the anastomosis to dilate and provide a by-pass for an occluded portal vein. Due to technical difficulties, it has not been practicable to measure blood flow through the shunt. It is intended to obtain an approximate estimate of this flow by the use of cine-angiography and by dye-dilution curves. The ability of the shunt to dilate in order to accommodate the increased flow of blood due to portal hypertension is being investigated by performing spleno-pulmonary anastomosis on dogs in which portal hypertension has previously been induced by the method of Kershner[2]. Furthermore, the effects are being examined of applying Kershner's procedures to animals already having the shunt.

Spleno-pulmonary anastomosis, if used in the alleviation of portal hypertension due to extra-hepatic venous block in children, would return portal blood to the left side of the heart. Calculation suggests that this would not overload the heart and would not appreciably affect oxygen saturation in the left atrium.

A parenchymatous surgical approach to the problem of portal hypertension has been described by Felder[3]. He demonstrated vascular connexions between the coapted surfaces of the decapsulated liver and spleen

Fig. 4. High-power view (× 60) of area shown in Fig. 3, showing dilated veins in line of fusion of spleen and lung. Veins (*V*), arteries (*A*) and thickening of a vein (*VA*) probably due to anastomosis with a small artery

in rabbits, and showed that this procedure increased the time of survival following ligation of the portal vein.

A procedure in which portal blood was returned to the right side of the heart through an anastomosis between the spleen and intercostal veins has been performed in humans by Turunen[4]. Following the placing of the intact spleen inside the thorax, venous connexions developed between the spleen and the pleura, and bleeding œsophageal varices improved.

We suggest that spleno-pulmonary anastomosis as a shunt in portal hypertension should prove superior.

Parenchymatous anastomosis may possibly provide a better method of treatment of portal hypertension in children than the present unsatisfactory procedures.

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BIOCHEMICAL MECHANISM OF LESION FORMATION IN VIRUS-INFECTED PLANT TISSUES

By Dr. F. SOLYMOSY, Dr. G. L. FARKAS and Dr. Z. KIRÁLY
Research Institute for Plant Protection, Budapest

THE formation of local lesions is one of the most striking symptoms of virus diseases discovered as early as 1929 by Holmes[1]. Strangely enough, little is known about the metabolic disorders leading to the development of these necrotic spots. They are regarded as 'protective mechanisms' localizing the pathogenic agent to restricted areas of the host tissues due to the total disorganization and breakdown of protoplasmic structure in a small group of host cells highly sensitive to the invading parasite[2]. The local lesions of various host plants attacked by special virus strains and those of resistant wheat plants infected by rust fungi are the most typical examples of lesion formation due to 'hypersensitivity'[3]. Recent ideas concerning the metabolic aspects of defence reactions based on hypersensitivity in resistant wheat plants emphasized the probability that the balance of oxidizing and reducing systems acting on polyphenols is upset in the diseased areas, resulting in the accumulation of toxic polyphenol oxidation products killing the host tissues[4]. Experimental evidence in support of this view has recently been presented by Király[5]. It seemed, therefore, worth while to extend these studies to the problem of virus-induced lesion formation.

The leaves of experimental plants (*Nicotiana tabacum* var. Samsun, *N. glutinosa*, *Datura stramonium*) were inoculated mechanically at an early stage of development (6–8 leaf stage) with tobacco mosaic virus, cucumber mosaic virus or tobacco necrosis virus. When the local lesions appeared (second or third day after inoculation) polyphenoloxidase activity was measured in tissue homogenates by the use of conventional manometric techniques. The catechol–hydroquinone system[6] was chosen as substrate. The results are expressed as Q_{O_2}-values: increase in uptake of oxygen on addition of substrate in mm.^{3} oxygen/mgm. dry matter/hr. As a gradual decrease in activity of polyphenoloxidase was experienced in the course of measurements, results were calculated on the basis of readings taken during the first 10–15 min. Representative examples are given in Table 1.

As shown in Table 1, a considerable increase in activity of polyphenoloxidase was found whenever the host–virus combination resulted in the appearance of local lesions, whereas no similar stimulation was observed when the virus spread systemically, except in a very late stage of systemic infection. This latter observation on systemically infected plants is in agreement with recent findings of Martin[7]. His claims for another smaller maximum of polyphenoloxidase activity in systemically infected tobacco plants at an early stage of infection, however, could not be verified using (to secure reliable controls) the half-leaf method.

Table 1. Effect of Virus Infection on the Polyphenoloxidase Activity of Host Tissues

Host plant	Tobacco mosaic virus		Tobacco necrosis virus		Cucumber mosaic virus	
	H	I	H	I	H	I
N. glutinosa	0·2	4·5*	0·2	2·1*	0·2	0·5
N. glutinosa†	—	—	—	—	5·1	9·9
N. tabacum var. Samsun	8·7	9·3	8·7	12·6*	—	—
Datura stramonium	0·6	9·6*	—	—	0·6	1·8

Polyphenoloxidase activity: expressed as increase in oxygen uptake in mm.^{3}/mgm. dry matter/hr. upon addition of substrate.
H, healthy; I, infected.
* Combinations resulting in the development of local lesions.
† Polyphenoloxidase activity tested six weeks after infection. The control was of the same age.

If the accumulation of polyphenol oxidation products, due to an *in vivo* stimulated activity of phenol oxidizing enzymes, were the immediate cause of lesion formation, this latter should be inhibited by the administration of compounds able to reduce quinones or inhibit their formation under physiological conditions. Ascorbic acid is able to reduce quinones chemically. In addition, the inhibitory effect of ascorbic acid on some polyphenolases has been reported[8]. Glutathione and cysteine are also powerful reducing compounds, and *in vitro* inhibition by glutathione and cysteine of the accumulation of polyphenol oxidation products was described[9]. Therefore, the above compounds were infiltrated into detached *N. glutinosa* leaves, the excess of water evaporated, and the leaves infected with tobacco mosaic virus. The infected leaves were then placed with their petioles in test-tubes containing the same solutions and after two days the number of local lesions counted. The results were clear-cut (see Table 2). All the three compounds, if applied in adequate concentration, strongly inhibited lesion formation (10^{-2} *M*). The most effective was ascorbic

Table 2. THE EFFECT OF REDUCING SUBSTANCES ON LESION DEVELOPMENT IN *Nicotiana glutinosa* INFECTED WITH TOBACCO MOSAIC VIRUS

Substance infiltrated	Average number of lesions*	
	Infiltrated	Control
Ascorbic acid 10^{-2} *M*	2	37
Glutathione 10^{-2} *M*	6	42
Cysteine 10^{-2} *M*	5	30

* Average of five consecutive experiments.

acid, usually reducing the number of local lesions to zero.

This effect is apparently based on a chemical *in statu nascendi* reduction of the quinones formed. This is indicated by the fact that a high level of reducing compounds must be maintained in the tissues in order to inhibit lesion development. When after infiltration with 10^{-2} *M* ascorbic acid the leaves were placed in water instead of ascorbic acid solution the treatment proved more or less ineffective due to the rapid metabolization of the compound infiltrated. Direct measurements (iodometric titration) indicated that the concentration of reducing compounds of the leaves must be raised 7–8 times and maintained at this high level in order to inhibit lesion formation. This explains the failure of Wiltshire[10] to obtain the inhibition of lesion development by ascorbic acid in beans infected with tobacco necrosis virus. He raised the endogenous ascorbic acid concentration to a lesser extent.

The concentration of ascorbic acid applied may be regarded as physiological. The inhibition is evidently not due to any unspecific damage to the leaf metabolism since it is reversible. Although complete inhibition is achieved by the end of the second day after infection, the lesions will later appear if the concentration of ascorbic acid is allowed to decrease. With cysteine and glutathione symptoms of toxicity appeared after about 24 hr. To reduce the toxic effect these compounds were infiltrated into the leaves 24–36 hr. after infection. Even in this case the margins of some leaves were slightly damaged. The development of local lesions was, however, arrested in the unaffected areas of the leaf surface as well.

The complete abolition of lesion formation in leaves treated with ascorbic acid favours the view that the development of lesions results from an accumulation of quinones due to an enhanced polyphenoloxidase activity and possibly also to a virus-induced breakdown of reducing systems in some cases. The disorganization of cell structure in itself does not lead to an increased activity of polyphenoloxidase. When leaf tissues of *N. glutinosa* were damaged with a needle evoking 'lesions' strikingly similar to those induced by tobacco mosaic virus, the activity of polyphenolases, measured 24 hr. after damaging, has not shown any increase comparable to that occurring in leaves with virus-induced lesions. This is further evidence to show that the enhanced activity of polyphenoloxidase in virus-infected leaves is a cause and not a result of cellular breakdown and it is actually the mechanism responsible for the hypergergic reaction localizing the pathogen and inhibiting its generalization.

As judged from transmission experiments the virus did multiply in the treated tissues but this has not led to the appearance of local lesions in the presence of reducing compounds. Experiments are in hand to decide whether or not a generalization of the virus occurs in this case.

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CRYSTALLOGRAPHIC STUDIES OF THE BIURET REACTION

By DR. H. C. FREEMAN, J. E. W. L. SMITH and J. C. TAYLOR*
School of Chemistry, University of Sydney

THE bonding between metal ions and peptides is a subject of increasing biochemical interest. Metal-peptide complexes appear to be involved *inter alia* in the transition-states of metal-activated proteolytic enzyme reactions[1,2], in the inhibition of the gelation of gelatine by cupric ions (ref. 3 and Kiefer, M., and Vinograd, J. R., private communication), and in the formation of the colours of metal-protein solutions[4–8]. Hitherto, the evidence for the structures of such complexes has been drawn from measurements on solutions, since insufficient analogy exists between them and the few amino-acid chelates the crystal structures of which have been studied[9–11]. We have therefore begun structure determinations of several compounds intended to be models for peptide-metal interaction. In this communication we wish to report those features of two of these structures which appear to be of biochemical significance.

* Present address: Australian Atomic Energy Commission, Lucas Heights, New South Wales.

As a starting-point we have used the well-known fact that, when cupric ion is added to an alkaline solution of a protein or polypeptide, a violet-red colour is produced. The reaction is a general one, obviously involves the formation of a metal-peptide complex, and has been used in qualitative and quantitative tests for proteins. The violet-red colour is reversibly changed to blue upon acidification of the solution. The simplest substance which shows this behaviour is biuret, $NH_2CONHCONH_2$, and the reaction has accordingly become identified with the name of this compound.

We have carried out X-ray crystal structure determinations of two substances—potassium *bis*-biuret cuprate(II) tetrahydrate, $K_2[Cu(NHCONHCONH)_2].4H_2O$ (substance *a*), and *bis*-biuret copper(II) chloride, $[Cu(NH_2CONHCONH_2)_2]Cl_2$ (substance *b*). The former is the violet 'parent compound' of the biuret reaction. It was prepared by shaking fresh cupric acetate with a solution of biuret dissolved in

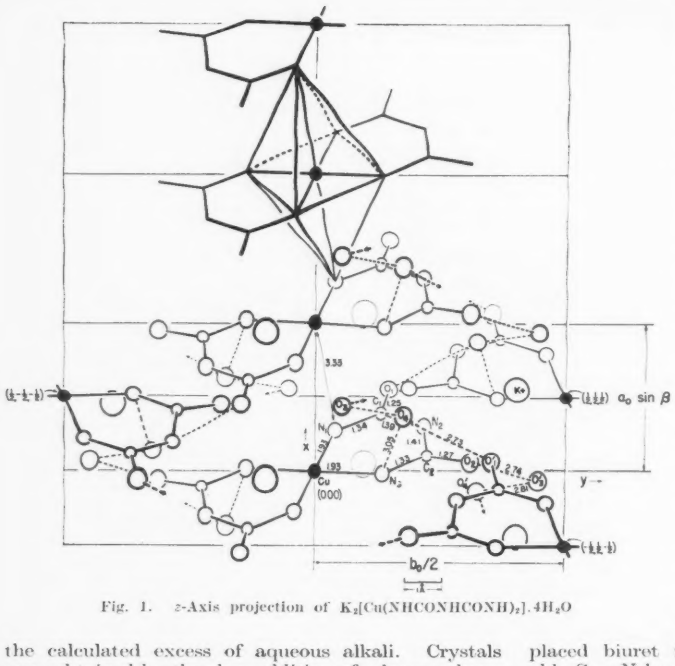

Fig. 1. z-Axis projection of $K_2[Cu(NHCONHCONH)_2].4H_2O$

the calculated excess of aqueous alkali. Crystals were obtained by the slow addition of a large volume of alcohol containing a little potassium hydroxide. The second compound formed tiny pale blue-green crystals when a warm alcoholic mixture of cupric chloride and biuret was gradually cooled. Both complexes were unstable in air but the crystals were adequately protected against decomposition by a thin film of collodion.

Substance a is monoclinic, $a = 3{\cdot}84$ A., $b = 13{\cdot}32$ A., $c = 13{\cdot}92$ A., $\beta = 94°\ 5'$. The space-group is $P2_1/n$. There are two formula units in the unit cell, and these must therefore be centred about copper atoms at the origin and $(\frac{1}{2},\frac{1}{2},\frac{1}{2})$. Substance b is orthorhombic, $a = 6{\cdot}83$ A., $b = 8{\cdot}03$ A., $c = 10{\cdot}74$ A. There are two formula units in the unit cell; but there is an ambiguity between the allowed space-groups $Pnn2$ and $Pnnm$. While the copper atoms are at (0,0,0) and $(\frac{1}{2},\frac{1}{2},\frac{1}{2})$ in either case, only the second of the two possible space-groups would confer centrosymmetry on the complex.

For the violet compound a our data consist of the absorption-corrected intensities of about 1,000 X-ray reflexions, visually estimated on Weissenberg diffraction photographs obtained with copper K_α-radiation. The structure has been refined by the method of least-squares, giving a conventional crystallographic reliability factor $R = 0{\cdot}079$ and standard-deviations of the bond-lengths and bond-angles of about 0·01 A. and 1·6° respectively. The parameters for the anisotropic thermal vibrations of all the atoms (other than the hydrogens) have been computed. The final refinement cycles have produced evidence for the locations of the hydrogen atoms, and it is on the basis of these that we can assign to the compound the formula given above (as distinct from, for example, $K_2[Cu(NH_2CONHCONH_2)_2](OH)_4$). The structure analysis of substance b has progressed to the stage where there is no doubt about the general structure. With a single isotropic temperature parameter for all atoms the R-factor is 0·127 for 429 hKl reflexions ($K = 0$–4), of which one-third were unobservably weak; for those 176 reflexions to which the copper atom makes no contribution, R is 0·152. The two structures are shown diagrammatically in Figs. 1 and 2, which are projections along the z-axis of a and the x-axis of b, respectively.

The copper atoms are square-co-ordinated in both complexes. In the violet compound a, the square-planar arrangement of ligand atoms involves the peptide nitrogen atoms N_1 and N_3 of two symmetrically placed biuret residues. The bonds have reasonable Cu—N lengths of 1·93 A. Successive complexes are stacked at such an inclination to the (100) plane that each nitrogen atom N_1 of one complex also lies exactly at one of the apices of an elongated octahedron about the copper atom of an adjacent complex. The arrangement is illustrated in the upper half of Fig. 1. The distance between the copper and the octahedral nitrogen atoms is 3·33 A., implying that only weak interaction is possible. The closeness of approach between complexes has, of course, a

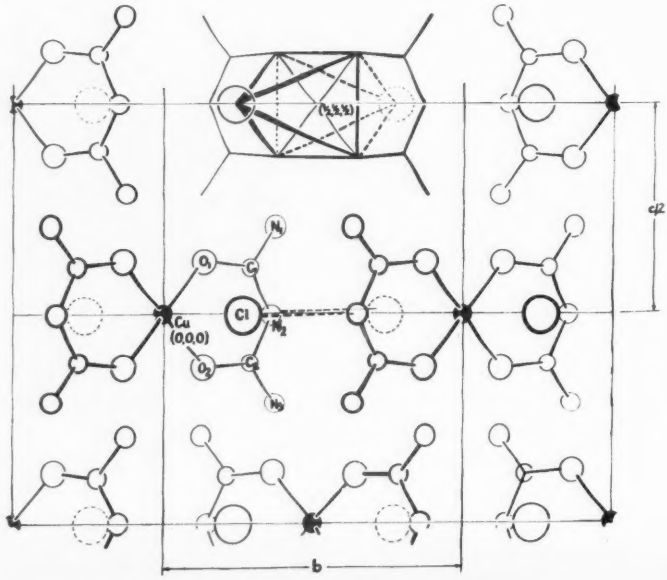

Fig. 2. x-Axis projection of $[Cu(NH_2CONHCONH_2)_2]Cl_2$

lower limit set by the van der Waals' radii. It turns out that the Cu—N vector represents the shortest distance between any two atoms of adjacent complexes.

The bond-lengths and bond-angles of the amide-groups in *a* are not significantly different from those reported for the biuret molecule in the crystal of biuret hydrate[12]. This indicates that the substitution of a co-ordinated copper for an amide hydrogen atom does not seriously disturb the bond-orders and resonance in the amide group. As in biuret hydrate, so in *a* the biuret residue is not flat. Each biuret residue is bent slightly about the line joining Cu to N_2, the two halves then being twisted in opposite senses about the bonds C_1—N_2 and C_2—N_2. As a result of this distortion there is an angle of about 5° between the normals to the two planes containing, respectively, $N_1C_1O_1N_2$ and $N_2C_2O_2N_3$. Neither amide group lies strictly in the plane of the copper atom and the four attached nitrogen atoms. In fact, even if we ignore the non-planarity of the two biuret molecules co-ordinated to a copper atom, the complex is bent by about 2·5° on each side of the co-ordination square along the line adjoining N_1 and N_3 of the ligand.

The water molecules and amide groups in substance *a* are linked by a network of hydrogen bonds, albeit not a particularly efficient one. If we superscribe the atoms of the complexes centred on $(-\frac{1}{2},\frac{1}{2},-\frac{1}{2})$ and $(\frac{1}{2},\frac{1}{2},-\frac{1}{2})$ with ′ and ″ respectively, then hydrogen bonds link $O''_2 \ldots O_3$, $O_3 \ldots O_4$, $O_1 \ldots N_3$ and $O_4 \ldots O'_1$. The potassium ion fits into a hole in the structure (a fact which does not emerge very clearly from Fig. 1), being at the centre of a trigonal prismatic arrangement of four amide oxygen atoms and two water molecules at $K^+ \ldots O$ distances between 2·7 and 2·9 A.

A closer examination of the configurations about the ligand nitrogen atoms in *a* leads to the important conclusion that considerable distortions from the normal bond-angles may occur at the sites of co-ordination. The angles Cu—N_1—C_1 and Cu—N_3—C_2 are both 131°. The vector from N_1 to the copper atom of an adjacent complex makes an angle of approximately 90° with both the N_1—Cu and N_1—C_1 bonds. The hydrogen atoms which are attached to N_1 and N_3 do not appear to be involved in hydrogen bonds, and their *x*-co-ordinates are not in fact as accurately known as the other hydrogen-parameters in the structure. These two hydrogen atoms appear to lie only slightly out of the plane of the copper and nitrogen atoms. Approximate values of the bond-angles are: Cu—N_1—H, 119°; C_1—N_1—H, 108°; Cu—N_3—H, 112°; C_2—N_3—H, 115°. This places the hydrogen atom attached to N_3 on the line between N_3 and the water-O_4 atom of the next unit-cell in the $-x$ direction, although the distance of 3·35 A. makes it unlikely that a hydrogen bond is here involved. N_3 is, on the other hand, definitely hydrogen-bonded to the water-molecule represented in Fig. 1 by O_4. This $N_3 \ldots O_4$ bond lies at angles of 112° and 94° from the bonds N_3—Cu and N_3—C_2.

The blue compound *b* also has two biuret molecules bonded to each copper atom via four donor atoms arranged at the corners of a square. In this case the octahedral positions are occupied by chloride ions at normal Cu—Cl^- distances of 3·0 A., while the donor atoms at the present level of refinement appear to be at 1·92 A. from the metal atom.

The most interesting difference between *a* and *b* is that in $[Cu(NHCONHCONH)_2]^{=}$ the metal-peptide bonding is via the peptide *nitrogen* atoms, while in $[Cu(NH_2CONHCONH_2)_2]^{++}$ at least two, probably four, of the donor atoms are peptide oxygen atoms. At every refinement stage we have recalculated all structure-factors for models having as the ligand atoms respectively four oxygen atoms, two oxygen and two nitrogen atoms, and four nitrogen atoms. The agreement between the calculated and observed structure-factors for the first of these models has been consistently and significantly better than for the third, and consistently and slightly better than for the second.

At the present stage of refinement of *b* a more detailed description of the ligand is impossible. It is quite clear, however, that the complex is bent similarly to *a*, and that the plane of each biuret molecule makes an even larger angle (of about 23°) with the plane containing the copper and donor atoms.

By contrast with *a*, the structure of *b* is held together mainly by the electrostatic forces between the complex cations and the chloride anions. The only certain hydrogen-bonded contact is that between the secondary nitrogen atom N_2 and a chloride ion which lies at 3·2 A., almost exactly along the line which bisects the angle C—NH—C. The complexes lie perpendicular to (001), and a projection of the structure along the *z*-axis would show the compact arrangement of complexes and Cl^- ions in this plane.

It has been pointed out by Rabin[16] that, unless a peptide hydrogen atom is lost by dissociation, co-ordination at a peptide nitrogen atom causes the loss of the resonance energy of an amide group. Under neutral or acid conditions, co-ordination at the peptide oxygen atom is therefore expected. At first sight, this view gains strong support from the structure of *b*, which is precipitated from a neutral alcoholic solution. We have not, however, succeeded in showing that the ion $[Cu(NH_2CONHCONH_2)_2]^{++}$ indeed exists in other than the solid state. A neutral aqueous mixture of cupric sulphate and excess biuret has an absorption curve between 200 and 1,000 mμ which is indistinguishable from that of the hexaquo-copper(II) ion, and the absorption curve of an alcoholic solution of cupric chloride between 230 and 1,000 mμ is unaffected by the addition of alcoholic biuret solution until precipitation occurs.

On the other hand we find, in agreement with Kober and Haw[17], that the violet complex *a* in aqueous solution has an absorption maximum at $\lambda_{max.} = 505$ mμ with $\varepsilon_{max.} = 43$. The structure analysis thus provides evidence that absorption at this wave-length is indeed characteristic of copper(II) co-ordinated by four peptide nitrogen atoms[8a,17], it being assumed that the complex *a* has the same structure in solution as in the solid (with the probable addition of two water molecules in the octahedral positions).

Finally, our results for the first time confirm a structure which was suggested for the violet copper–biuret complex by Tschugaeff in 1907 [4]. They also support the view[1,13,15,16] that in alkaline solution the ionization of peptide hydrogen atoms is responsible for the additional dissociation constants found for the copper complexes of some peptide ligands, and that metal-peptide binding then occurs via peptide nitrogen atoms.

Detailed descriptions of the structures and particulars of the methods of refinement are being published elsewhere. Concurrently with the further refinement of *b* we are investigating the crystal structures of the cupric complexes of tri- and tetra-glycine with

the intention of initiating a systematic attack on the structural questions involved in metal-peptide systems via suitable model compounds.

Parts of this work were carried out during the tenures of a George Ellery Hale fellowship at the California Institute of Technology (H. C. F.), and of an Australian Atomic Energy Commission studentship (J. C. T.). Our first crystal specimens were given to us by Dr. B. M. Gatehouse and Dr. R. J. Irving (University of New South Wales). Helpful discussions with them and with Drs. A. McL. Mathieson, B. R. Rabin, T. M. Dunn and R. W. Green are gratefully acknowledged.

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COLOUR-IMAGE SYNTHESIS WITH TWO UNORTHODOX PRIMARIES

By ARTHUR KARP
Engineering Laboratory, University of Cambridge

DR. E. H. LAND, in his recent articles[1,2] and interesting lecture to the Royal Photographic Society last year, has revived interest in the art of synthesizing coloured images with only two primaries. The technique is to superpose on a screen the images of two black-and-white slides contained in two projectors having individual coloured light sources. The slides for the two projectors, here designated L and S, are always prepared by photographing a scene through red and green filters so that the transparent areas of each slide correspond to light reflected from the scene in the spectral intervals red-to-yellow, and yellow-to-cyan (blue-green) respectively. The choice of hues for projection, or for the dyes or inks to be printed on film or paper, however, is open. The standard combination, as used in 'Sovcolor', the original 'Warnercolor', and their numerous predecessors[3], is red-orange and blue-green. Fox and Hickey, more than fifty years ago, and the Raycol Company, in 1929, employed red and white[3].

By studying these and very many other pairs of projecting primaries in careful experiments, Land has been able not only to create some effective colour pictures, but also to report some new and accurate measurements. For example, a surprising gamut of hues, including red, white and blue, may be seen when the S illuminant is greenish-yellow (dominant wavelength $\lambda_S = 579$ mμ) and the L illuminant is orangish-yellow ($\lambda_L = 599$ mμ). With regard to other primary colours, the number of different hues that may or may not be visible in the final result is a function of the primaries. To summarize his findings, Land has designated, on a chart having λ_S and λ_L as co-ordinates (ref. 2, p. 89), hereinafter referred to as Land's colour map, domains indicating the unobtainable final subjective hues. To summarize his investigations of how each hue is produced in an image, Land constructed another chart, called the dimensionless co-ordinate system (ref. 2, 89), where the names of all the hues are attached to points the co-ordinates of which are the relative L and S illuminations of a spot in a synthesized picture where the particular colour was seen. Relative L illumination is defined as the actual intensity of L light at the spot divided by the maximum intensity of L light anywhere in the picture.

Many of the above facts have been verified by experiments at the Cambridge University Engineering Laboratory. For example, the red-and-white primary combination does allow bluish and greenish hues to appear on the screen, or in a Kodachrome photograph of it, although detailed examination of each image point in isolation reveals nothing but mixtures of red, white and black, even in regions which take on bluish or greenish hues when the isolation is incomplete. The term 'in isolation' denotes that an image point is examined by a means which excludes the remainder of the image, including details, such as a highlight, of the object of which the point is a part. It also denotes that the eye has not been exposed to any coloured fields immediately prior to the observation.

Land has also reported[1,2] that nothing but shades and tints of red can be seen when the S and L slides are wedge filters, giving a gradual change from black to white, oriented as in Fig. 1*a*, so that the gradations run from top to bottom in one projector and from left to right in the other. We modified this experiment by using stepped wedges overlaid by either a black or a white network to form detached squares against a background (Fig. 1*b* and *c*). The results in *b* were monochromatic as in *a*; but with the white network *c* bluish-green hues dramatically appeared in the positions indicated. Points of the network, or background, were pink when viewed in isolation through a small-apertured telescope, but in context appeared quite white. The bottom right-hand square was white in isolation, but cyan—the complementary of red—in context. Gelatine filters of various colours were then inserted in either or both of the projectors. Without a white background, only mixtures of the original primaries were seen. Against the white background, colours that were easily recognized as mixtures of two new primaries became visible. Each new, or revised primary, was in turn recognized as one of the original primaries mixed with the

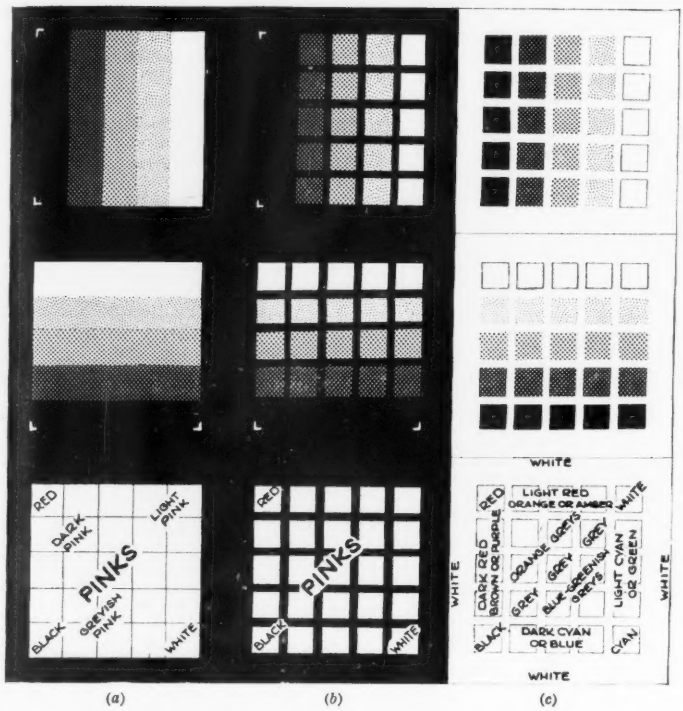

Fig. 1. Method of projecting array of squares with slides of horizontal and vertical step wedges. *a*, No background; *b*, black background; *c*, white background. Top row: slides for *S* projector; second row: slides for *L* projector; bottom row: subjective result with red *L* and white *S* primary illuminants

complementary of the other. This prevalence of complementary-hue generation strongly suggests that the physiological and/or psychological effects that occur in unorthodox two-colour synthesis are probably related to those which occur in simultaneous or successive contrast, as in the striking experiment wherein a red light instantly appears cyan—or a green light, magenta—when viewed through a hole in a rotating disk the surface of which is half white and half black.

The remarkable contribution of the subjectively white background suggested other experiments with white cues. Whatever the primary hues, it was found that a synthesizable composition had to include areas which were psychologically more acceptable when neutral, such as a border or background which could be white or grey or even a rather dark grey. Excellent, though subtle, white cues are the highlights on glossy objects. Though very small they are hard to avoid in natural scenes other than landscapes, and, regardless of the colour of the underlying object, may provide the most intense white in the entire composition, as artists and television camera-men will confirm. The tolerance on mis-registration of the two constituent images was found to be related to the loss of identity of the tiny highlights in the scene.

Only occasionally did the masking-off of all white cues fail to remove completely the impressions of cyan in a red-and-white synthesis. Even then, the residual impression usually faded away after several seconds. If it did persist, it was when red areas were nearby and simultaneous contrast was occurring. In this case the residual cyan would vanish after a pale blue gelatine filter was passed in and out of the beam of the *S* projector—a procedure which had no effect on a picture containing white cues.

In each screen image, whether a still life or abstract composition, much was learned by watching (1) the *warmest spot*, (2) *coolest spot* and (3) *white cue*, as the primary colour filters were changed and/or intensities of illumination varied. These three regions receive maximum light from (1) the *L*-projector alone, (2) the *S*-projector alone, and (3) both projectors, respectively, and may thus incidentally be associated with the datum levels of Land's dimensionless co-ordinate system. As the relative intensities of the primaries were varied, the subjective colour of the white cue appeared as a *desaturated* version of their mixture, and for many primary pairs, a point could be reached when the white cue object or region appeared as a "very good white". In brightness and hue, the apparent colour of the warmest spot was recognized as that of the *L* projector's light mixed classically with the complementary of the *S* projector's light, the intensity of the second component being small or large accordingly as the *S* projector's light was relatively dim or bright. For the coolest spot, read the foregoing sentence with *S* and *L* interchanged.

These results can be described more quantitatively with the help of the classical C.I.E. chromaticity chart[4]. As an example, Fig. 2*a* has been drawn for one of the remarkable pairs of primaries used by Land[2]—greenish-yellow *S* (579 mμ) and orangish-yellow *L* (599 mμ). Intensity is measured perpendicular to the page, so that the chart represents lines and planes in colour space projected into the plane having medium neutral grey at O. All the physical chromaticities of the projected scene lie in the line *LS*. As light intensities are varied, the physical chromaticity of a white-cue spot (*W*) obviously moves along *LS*, but its subjective chromaticity is seen to depart from *LS* and follow the dashed curve *LW'S*. The separation O*W'* at the closest approach to O is exaggerated in the figure, for it is usually small if *W* originally falls in a yellow or other light or desaturated region of the chart. The reason for the shift of *W* to *W'* is probably psychological, and may be accompanied by a physiological process giving involuntary and rapid adjustment of the sensitivities of one or more of the retinal or cortical colour sensors in the direction of restoring the neutrality of hue of the parts of the image which the observer, perhaps subconsciously, expects or prefers to be neutral. (In projecting conventional colour transparencies, one may also observe the tendency to retain the whites and greys in the original picture when a flood of coloured light is superposed.) Possibly because of retinal or cortical

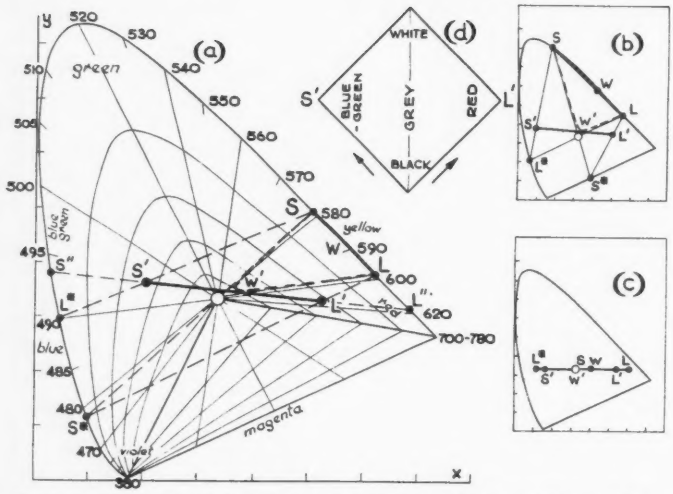

Fig. 2. Transformation of physical locus of chromaticities (SL) to mental locus of chromaticities ($S'L'$) via the white-cue effect. *a*, Primaries 579 and 599 mμ; *b*, primaries 535 and 589 mμ; *c*, primaries white and orangish-red; *d*, final colour plane

interconnexions, the observer's controls seem to act as well over the remainder of whatever scene is sharing a common frame with the white cues, and the effect is one of partial subtraction of the original primaries over the area within this frame.

The subjective chromaticity of the warmest spot lies at L' between L and the complementary of S, that is, S^*. The distance LL' increases as the relative intensity of S is increased. Similarly, the coolest spot's chromaticity S' lies on SL^*, with $SS'/S'L^*$ depending on the ratio of the intensities of L to S, which is set when adjusting for the best rendering of white and grey. The subtractions have produced revised primaries, S' and L', and a revised locus, $S'W'L'$—virtually $S'OL'$—for all the subjective hues of the scene which, at the price of desaturation, is seen to embrace a much larger range of hues than SL (ref. 2, p. 86). Replacement of the monochromatic primaries with gelatine-filtered light of the same dominant wave-lengths shifts S, L, S^* and L^* to points slightly inside the spectrum locus, with little effect on the result. Similar diagrams (Fig. 2*b*) are readily constructed for any other primary combination including those in which one member of the pair is white (Fig. 2*c*). The colours in $S'L'$ are all desaturated to roughly the same extent, so that one usually obtains a pleasingly restrained and dignified[3] artistic effect like that of a water-colour painting. Primaries such as S'' and L'', for example, lead to similar final hues; but the effect can be harsh or gaudy.

When $S'L'$ is roughly parallel to the x axis, Land's co-ordinate system can be related to the plane through $S'L'$ normal to the page (Fig. 2*d*). For other orientations of $S'L'$, the hues lying far from $S'L'$ correspond to those stated to be unobtainable in Land's colour map. For example, when $S'L'$ runs from blue to yellow, it gives wide berth to red, green and magenta. When the primaries are blue L (440–510 mμ) and violet S (400–435 mμ), the construction makes S' and L' fall in the magenta and green regions, respectively. Not only are all other hues now unobtainable, but the revised cool primary S' is now warmer (redder) in aspect than L'. (See the region marked "short wave reversal" in Land's colour map.)

A final problem concerns the fact that some of the colours, such as yellow, purple, deep blue, etc., which are sometimes seen in synthetic still life and other compositions, do not lie within $S'L'$ (Fig. 2*d*) which, to use an analogy, has only "four paints on its pallette"—red, cyan, black and white. Numerous experiments with many observers suggest that a psychological factor, probably related to the effect of the picture on the observer's emotions, determines whether the subjective colours will be limited to those of $S'L'$ or whether hues from closely adjoining regions in the C.I.E. chart may be co-opted by the imagination. For example, with synthesized pictures of most geometrical patterns, or of an uninteresting collection of variously coloured but otherwise identical polished plastic spheres, no colours outside the limited range of $S'L'$ were noted in the projected image by indifferent observers to whom no suggestions were given. However, if suggestions were given, or if the scene possessed the least trace of human interest, $L'S'$ colours such as cyan, dark desaturated cyan, light pink and dark grey might convincingly appear to some observers, respectively, as a green, blue, yellow and violet of the same lightness, and a low-intensity red could sometimes appear either as chocolate, claret, mahogany, or purple. When viewing the array-of-squares projections (Fig. 1*c* bottom) some observers reported seeing spectral sequences in the rows or columns and named individual squares as amber, orange, purple, indigo, etc. Unanimous agreement among normal observers, however, could only be approached when the objects actually were of an $L'S'$ colour, or when they had an established identity, such as daffodils, ivy leaves, a croquet set, hair, sky, a Chinese teacup, etc.

To conclude, we believe that, in conjunction with the phenomenon of overlapping in the subjective distinctions between colours of equal lightness and adjacent hue, the white-cue effect—which, in restoring the sensations of white and grey to a framed image, causes the original primaries of that frame each to be modified by the addition of the complementary of the other—adequately explains the various phenomena associated with the unorthodox two-colour synthesis of images of natural objects.

I am indebted to Prof. W. R. Hawthorne for his generous sponsorship and encouragement of the project and many helpful discussions and suggestions. The valuable comments of Dr. W. A. H. Rushton and Dr. E. N. Willmer are gratefully acknowledged, as is the technical assistance of Messrs. E. R. Mudd, E. D. Nisbet, L. R. Peters and the staff of the Engineering Laboratory Workshop under A. A. Barker. Thanks are also extended to the scores of observers whose comments are a necessary part of any subjective study.

[1] Land, E. H., *Proc. U.S. Nat. Acad. Sci.*, **45**, 1, 115; 4, 636 (1959).
[2] Land, E. H., *Sci. Amer.*, 84 (May 1959).
[3] Cornwell-Clyne, A., "Colour Cinematography", third ed. (Chapman and Hall, Ltd., 1951).
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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 26

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Prof. Michael J. Wise: "Great Cities of Japan".

UNIVERSITY COLLEGE (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. Fleckenstein (University of Freiburg): "The Metabolism of Labile Phosphate Compounds in Living Muscle, Studied with Radioactive Phosphorus and Paper Chromatography". (First of two lectures on "Isotopic Studies of Phosphorus Metabolism in Skeletal and Heart Muscle". Further lecture on October 28.)*

UNIVERSITY OF LONDON (at Birkbeck College, Malet Street, London, W.C.1), at 6 p.m.—Prof. E. G. Boring (Harvard University): "Current Trends in American Psychology". (Last of three lectures on "The Pattern of Modern Psychology".)*

Tuesday, October 27

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. Elizabeth M. Deuchar: "How Embryos Develop—Grafting Experiments and the Organiser Concept".*

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Future Trends in Memory Stores for High-Speed Digital Computers", opened by Mr. W. Renwick.

ILLUMINATING ENGINEERING SOCIETY (at the Federation of British Industries, Tothill Street, London, S.W.1), at 6 p.m.—Mr. A. N. Irens: "Light and Productivity" (Golden Jubilee Lecture).

INSTITUTION OF MECHANICAL ENGINEERS, AUTOMOBILE DIVISION (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. Leonard Raymond: "Engineering Challenges to American Automotive and Petroleum Research".

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. J. H. Bach and Mr. G. E. Fishter: "Modern Developments in Optical Instruments".

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, in association with GRANADA TV NETWORK, at the Guildhall, London, E.C.2), at 8.30 p.m.—Sir Eric Ashby: Third of the Inaugural Series of the Granada Lectures on the theme of "Communication in the Modern World".

Wednesday, October 28

INSTITUTION OF ELECTRICAL ENGINEERS, ELECTRONICS AND COMMUNICATIONS SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. M. J. L. Pulling: "Development of Eurovision" (Chairman's Address).

INSTITUTION OF MECHANICAL ENGINEERS, APPLIED MECHANICS GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Prof. J. L. M. Morrison, Prof. B. Crossland and Dr. J. S. C. Parry: "Strength of Thick Cylinders Subjected to Repeated Internal Pressure".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP—NUTRITION PANEL (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Mr. A. E. Bender and Mr. B. H. Doell: "The Nutritionist and the Food Industry".

Thursday, October 29

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. G. E. Fogg: "Life on Mars".*

UNIVERSITY OF LONDON (at the Imperial College of Science and Technology, London, S.W.7), at 1.30 p.m.—Mr. S. J. Gould: "Industry and Society: 1—The Sociologists Look at Industry".* (First of five lectures. Further lectures on November 12, 19, 26 and December 3.)

UNIVERSITY OF LONDON (at the Senate House, London, W.C.1), at 5.30 p.m.—Dr. Kenneth M. Smith, C.B.E., F.R.S.: "Recent Work on the Electron Microscopy of Viruses".*

INSTITUTE OF PHYSICS (at 47 Belgrave Square, London, S.W.1), at 6 p.m.—Prof. G. O. Jones: "New Uses for Low Temperatures".

Friday, October 30

UNIVERSITY OF LONDON (at the Institute of Neurology, National Hospital, Queen Square, London, W.C.1), at 5.30 p.m.—Dr. Paul C. Bucy (Chicago): "Neural Mechanism Responsible for the Control of Motor Activity".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. F. C. Bawden, F.R.S.: "Plant Viruses: What They Are and What They Do".

Saturday, October 31

SOCIETY FOR FORENSIC SCIENCE (in the Lecture Theatre, Portland Building, University of Nottingham), at 10 a.m. and 2 p.m.—Inaugural Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

FELLOW OR SENIOR FELLOW IN PHILOSOPHY within the Department of Social Philosophy, Australian National University, Canberra—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 10).

ASSISTANT (with a degree in botany or horticulture or equivalent, and preferably experience in microscopy, and mathematical ability) IN THE POMOLOGY SECTION, for work on plant anatomy—The Secretary, East Malling Research Station, near Maidstone, Kent (November 15).

CHAIR OF METALLURGY in the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, November 15).

BIOCHEMIST (with two or three years research experience in agricultural chemistry, and preferably with M.Sc. or Ph.D. qualifications), for duties which include supervision of routine soil and plant analyses and research on the composition and properties of tobacco—The Director, Tobacco Research Board of Rhodesia and Nyasaland, P.O. Box 1909, Salisbury, Southern Rhodesia (November 16).

SENIOR LECTURER, LECTURER and a SENIOR DEMONSTRATOR IN PHYSIOLOGY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 16).

LECTURERS OR ASSISTANT LECTURERS IN BOTANY, CHEMISTRY, GEOGRAPHY, MATHEMATICS AND ZOOLOGY at the University of Malaya, Kuala Lumpur—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 20).

CHAIR OF ANATOMY tenable in the Newcastle Division of the University—The Registrar, University Office, 46 North Bailey, Durham (November 21).

LECTURER IN CIVIL ENGINEERING at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 27).

LECTURER (with qualifications in either pure or applied mathematics) IN MATHEMATICS at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, November 30).

MYCOLOGIST (with a good honours degree in botany with mycology as a special subject, a knowledge of the more fundamental aspects of animal and human mycoses, and preferably with a knowledge of Latin and other languages) at the Commonwealth Mycological Institute, Kew—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (November 30).

BIOCHEMIST (with M.Sc. or higher university degree), for work in the field of plant nutrition, with special reference to micro-elements and enzyme activity—The Director, Cawthorn Institute, Nelson, New Zealand (December 15).

CHAIR OF GEOGRAPHY in the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, December 15).

ASSISTANT OR ASSOCIATE PROFESSOR OF PATHOLOGY at Queen's University, Kingston, Canada—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Digest of Soviet Technology, No. 1 (April 1959). (Express Information on Recent Technological Developments in the Soviet Union and Eastern Europe.) Pp. 36. Annual subscription rate (12 issues) £6 6s. 0d. post free. (Kirkham, Preston: Engineering Information Services, 1959.) [287

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Committee of Privy Council for Medical Research. Report of the Medical Research Council for the year 1957–1958. Pp. viii+288. (Cmnd. 792.) (London: H.M. Stationery Office, 1959.) 13*s.* net. [297

Ministry of Labour and National Service. Annual Report of the Chief Inspector of Factories on Industrial Health for the year 1958. Pp. iv+61. (Cmnd. 811.) 3*s.* 6*d.* net. Annual Report of the Chief Inspector of Factories for the year 1958. Pp. 95. (Cmnd. 810.) 5*s.* 6*d.* net. (London: H.M. Stationery Office, 1959.) [307

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Ministry of Agriculture, Fisheries and Food. Fishery Investigations, Series 2, Vol. 22, No. 6: On the Nature of Production in the Sea. By D. H. Cushing. Pp. iii+40. (London: H.M. Stationery Office, 1959.) 10*s.* net. [58

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LETTERS TO THE EDITORS

CRYSTALLOGRAPHY

Transformation of Cubic Boron Nitride to a Graphitic Form of Hexagonal Boron Nitride

R. H. WENTORF[1] has reported that a fragment of borazon (synthetic cubic boron nitride) was twice heated to over 2000°C. *in vacuo* without change. Dr. Wentorf was kind enough to supply us with some small specimens, both black and yellow. Some of these, which gave random-rotation X-ray photographs showing them to be twins (only two nearly single crystals were found), we heated in graphite specimen holders in a high-frequency vacuum furnace (10^{-5} cm. mercury) in a series of experiments to compare their behaviour with that of diamonds of various kinds. Table 1 shows the effects given by subsequent X-ray powder photographs.

TABLE 1

Temperature	Time	Effect on boron nitride crystals
1500° C. (±20°)	5 min.	no change
1650° C.	3 min.	partial conversion to a hexagonal form of boron nitride
1800° C.	1 min.	complete conversion
2000° C.	1 min.	complete conversion
2200° C.	flash	complete conversion

The crystals retained their shape after conversion, but yellow crystals turned black. The partially converted and some of the specimens completely converted at 1800°C. showed preferred orientation, which Laue photographs indicated was of the same kind as that found for partially graphitized diamond. We hope to check this later on untwinned specimens.

R. S. Pease[2] has proved that the normal form of hexagonal boron nitride has atoms in positions N: 0,0,0 and $\frac{1}{3},\frac{2}{3},\frac{1}{2}$; B: 0,0,$\frac{1}{2}$ and $\frac{1}{3},\frac{2}{3}$,0. This form of boron nitride could not have transformed to cubic boron nitride (as graphite could to diamond) by a process of translation, compression and buckling of the hexagonal layers. Successive layers would first require to be rotated through 60° relative to each other, and this would mean considerable breaking up of the structure.

It is, however, noteworthy that the hexagonal boron nitride produced by heating the cubic form *in vacuo* is not the normal form. It is a graphitic form, in which, although the 000*l* and 1120 reflexions are sharp, the 1010 and 1011 form a single diffuse line, and $10\bar{1}2$ is very weak compared with 0004. The higher-angle reflexions rapidly fade in intensity. In these respects it is similar to the graphite formed by heating diamond *in vacuo*, which is not quite like terrestrial graphite, but is similar to the graphite found in meteorites[3].

The spacings of the graphitic boron nitride show that the unit-cell dimensions are identical with those of 'normal' hexagonal boron nitride. They are easily distinguishable from those of graphite itself, so that it was possible to prove conclusively that no contamination by the graphite crucible had occurred.

Specimens of normal hexagonal boron nitride (powder) were also heated similarly. No change except a slight annealing occurred up to 1800°C., but in experiments carried out at 2200°C., part of the specimens disappeared. X-ray photographs of the remains in the crucible showed that they had formed boron carbide, with the release of nitrogen. These experiments will be described in more detail elsewhere.

We are grateful to the Director of the A.E.I. Research Laboratory and to Dr. G. A. Geach, head of the Physical Metallurgy Section, for the facilities provided for heating the specimens.

H. JUDITH MILLEDGE
E. NAVE
F. H. WELLER
University College, London, W.C.1,
and
Research Laboratory,
Associated Electrical Industries,
Aldermaston Court,
Aldermaston, Berkshire.
Aug. 27.

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PHYSICS

Measurement of Asbestos Dust Concentrations with the Long-Running Thermal Precipitator

TESTS with a number of instruments in different factories have demonstrated that the long-running thermal precipitator of the type described by Hamilton[1] is a convenient instrument for measuring concentrations of asbestos dust in the atmosphere of card rooms, fiberizing departments and in other areas where the presence of asbestos dust may constitute a health hazard.

In this instrument, air is metered in cycles (which are intended to simulate breathing) through an elutriator and past a heated wire. Dust is deposited on a cover-slip, the heavier particles separating by elutriation and the finer particles being deposited by thermal precipitation at the end of the deposition area. The concentration of asbestos is determined by examining measured areas of the deposit microscopically and counting fibres of prescribed length.

Table 1 shows results which have been obtained with separate instruments in two different factories; one in Yorkshire, processing chrysotile asbestos; and the other in Essex, processing amphibole asbestos.

Table 1. ASBESTOS FIBRES/C.C. OF AIR (LENGTH-RANGE 5–100 μ)

	Duration of test	No. of tests	Fibres/c.c. average	Coefficient of variation (%)
Yorkshire Factory (Textile Dept.)	1 hr.	20	9·8	11
	2 hr.	20	4·7	18
Essex Factory (Fiberizing Department)	½ hr.	39	3·7	56
	1 hr.	41	3·4	49
	2 hr.	40	2·8	43

It will be seen that the calculated number of particles per c.c. of air appears to decrease as the running time of the precipitator increases. It is suspected that this may result from fibres being blown or washed off the slide by the air passing back over the deposit during the 'exhalation' part of the cycle.

Effects of this type have been noted with the Owens jet dust counter which works on the impingement

principle. Donoghue and Mack[2] have noted the effect with cotton fibres, and Davies, Aylward and Leacey[3] with dust particles. It has been assumed that particles deposited in the second half of one stroke when the air velocity is low may be blown off by the high velocities in the early part of the succeeding stroke.

It is understood that no such phenomenon occurs when isotropic particles such as coal or silica dusts are sampled in the thermal precipitator; but we have not heard whether the instrument has given satisfactory results elsewhere with asbestos or other fibrous dusts.

C. G. Addingley
British Belting and Asbestos, Ltd.,
Cleckheaton, Yorks.

R. Gaze
The Cape Asbestos Co. Ltd.,
Central Laboratory,
Harts Lane, Barking, Essex.

August 5.

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Sedimentation Rates, Fluidization and Flow through Porous Media

In a previous communication[1] I proposed a correlation of sedimentation rates by dimensionless groups, thus:

$$\psi = \frac{K}{B^N} \qquad \text{(I)}$$

The symbols throughout have the same meaning as before[1].

By analogy with the derivation of a correlation for a single free-settling particle, the resistive force per unit area for a suspension of particles sedimenting under hindered settling conditions is $\varepsilon(\sigma-\rho)g/S$. Thus, by the same procedure as before[1]:

$$B = \frac{U\rho}{(1-\varepsilon)S\eta_l} \qquad \text{(II)}$$

and

$$\psi = \frac{\varepsilon^3}{U^2 S}\,\frac{\sigma-\rho}{\rho}g \qquad \text{(III)}$$

Equation III differs from the corresponding previous equation[1] in the ε^3 term and it is proposed here because it is analogous to the equations for correlating fluidization phenomena[2]; sedimentation and fluidization are essentially similar.

Coinciding with the earlier communication[1] Orr and Dallavalle[3] proposed:

$$\frac{U^2}{Dg}\,\frac{1-\varepsilon}{\varepsilon^3} = \frac{1}{K}\,\frac{UD(\sigma-\rho)}{36\eta_l} \qquad \text{(IV)}$$

where D is equivalent diameter. This is an alternative form of equations I ($N=1$), II and III and was derived from Kozeny's permeability equation. Consequently, it assumes $N=1$ in the Blake-Carman correlation, thus losing generality. However, its authors, perhaps recognizing this, afterwards stated it in functional form.

The groups in equation IV are a modified Froude group and a modified Reynolds number (not the Blake number); thus, it is not in line with the usual methods for correlating similar flow phenomenon. However, its authors report successfully correlating a range of published data, some of which were mentioned previously[1], and an estimate indicates $K \sim 4{\cdot}3$. In addition, particle agglomerates, adhered fluid and surface area estimates have been dealt with by this method. These applications were mentioned previously[1] and consequently the two investigations overlap.

An empirical relationship for sedimentation which has recently been given a theoretical basis[4], is:

$$U = U_0\varepsilon^n \qquad \text{(V)}$$

The range of n was summarized previously[1]. At low Reynolds numbers the equation for a sphere settling under Stokesian conditions is usually used for U_0. Consequently, when $\varepsilon = 1$ equation V reduces to the relationship for a single sphere. However, because of the theoretical model, equations II and IV have no such meaning.

By examining the relationship between equations I, II, III and V, Table 1 was obtained:

Table 1. Variation of N and K with ε and n

	N			
ε	$n=4$	$n=5$	$n=6$	$n=7$
1·0	0	0	0	0
0·9	0·39	0·50	0·60	0·69
0·8	0·63	0·79	0·90	1·00 ($K=6{\cdot}11$)
0·7	0·79	0·96 ($K=3{\cdot}40$)	1·08 ($K=4{\cdot}86$)	1·18
0·6	0·91	1·08 ($K=3{\cdot}48$)	1·20	1·29
0·5	1·00 ($K=2{\cdot}00$)	1·17	1·29	1·37

Thus, if equation V holds, then equations I, II and III will give a shallow curve. This is not unexpected, because the correlation extends the Blake-Carman beyond its limit [$\varepsilon \sim 0{\cdot}5$ to $0{\cdot}7$] which occurs in the region of transition from flow through porous media to fluidization or to sedimentation.

Permeability equations of the form $u \propto \varepsilon^n$ ($n = 3{\cdot}3$–$7{\cdot}0$), where u is the rate of flow, have been proposed[5] but are rarely used in comparison to Kozeny's equation. These resemble equation V both in the porosity function (ε^n) and in the range covered by n. Data fitted by the Blake-Carman correlation[6,7] ($K = 3{\cdot}93$, $N = 1{\cdot}062$) were excellently described by the semi-empirical equation[7]:

$$kS^2 = 3{\cdot}3\varepsilon^{4{\cdot}95} \qquad \text{(VI)}$$

k is Darcy permeability and hence equations V and VI are of the same form in ε.

The flow phenomena considered here are fundamentally equivalent and similar correlation methods would reflect this. Although equations of the form V and VI have wide application, there appears to be more support for the Blake-Carman and similar correlations. The difference lies in the form of the porosity function; ε is possibly the most important variable whose influence is yet to be fully understood. Thus improved relationships might follow from introducing empirical porosity functions into the friction factor. However, the mention of correcting factors raises numerous possibilities. For example, tortuosity, particle shape and orientation and kinetic energy losses, which may be of considerable importance under certain conditions, might be treated thus.

Colin C. Harris
Department of Mining,
The University,
Leeds 2.

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GLACIOLOGY

Creep Tests on Antarctic Glacier Ice

THE strain rate of polycrystalline ice is known to depend on the applied stress, the temperature and the orientation of crystals in the specimen. From laboratory creep tests on randomly oriented ice, Glen[1] derived the simple flow law

$$\dot{\varepsilon} = k\sigma^n$$

where $\dot{\varepsilon}$ is the strain rate, σ is the stress, and k is constant for a given temperature. Other workers have confirmed the validity of this relationship for the stress range 2–15 bars. From observed minimum strain-rates Glen[1] deduced $n = 3{\cdot}17$; but he considered that a value of 4·2 derived from analysed quasi-viscous creep-rates was a more correct one for randomly oriented ice. Some observations on glacier tunnel deformation tend to confirm Glen's higher value for the exponent[2], whilst the closure of a borehole in the Greenland ice-cap gave an exponent of 3·77[3]. Other laboratory tests on glacier and commercial ice of high density gave figures ranging from 2·42 to 3·53 with a mean of 2·96[4]. Weertman's dislocation climb theory[5] calls for a dependence on stress to the power 4·5. Below a stress of 1 bar the flow mechanism is different and there is an approximation to viscous behaviour, with an exponent of about 1·5 applying.

As part of the International Geophysical Year work of the Australian National Antarctic Research Expeditions I, as the latter's glaciologist, conducted compression creep tests in the stress range 2–15 bars on randomly oriented antarctic ice at a temperature of −30°C. This ice is characterized by the inclusion of air under pressure in small (about 0·6 mm. diameter) bubbles, the density of the ice tested being approximately 0·87 gm./cm.^{3}. The exponent n for flow of this ice was found to be 4·2, suggesting that the cellular structure does not significantly alter the power in the relation between strain rate and stress.

Glen[1] also gave a relationship between strain-rate and temperature for a stress of 6 bars in the temperature range −1.5 to −13°C., assuming that the following equation holds :

$$\dot{\varepsilon} = A \exp\left(\frac{-Q}{RT}\right)$$

where A is a constant for a given stress, R the gas constant, Q the heat of activation and T the absolute temperature. Extrapolation of Glen's inverse linear relationship indicates that the value of the coefficient k in the flow law would be about 2×10^{-5} at −30°C., and Steinemann's[6] quasi-viscous creep-rates at a stress of 6 bars seem to confirm this figure. My results give $k = 5 \times 10^{-4}$ at −30°C., more than an order of magnitude larger. This indicates that the presence of numerous small air bubbles leads to easier deformation at a given stress and temperature. Under a stress of 6 bars the strain-rate of the bubbly ice at −30°C. was equal to the strain rate of the ice used by Glen at −10°C.

Full details of the tests are given in an A.N.A.R.E. Interim Report to be published by the Antarctic Division, Department of External Affairs, Australia.

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MALCOLM MELLOR

Meteorology Department,
University of Melbourne.

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METEOROLOGY

Nitrogen Content of Rain Water collected in the Humid Central Congo Basin

IT has been frequently assumed that in equatorial regions rain-water nitrogen was an important entry in the balance sheet of this element, and a great deal of speculation about this appears in the literature.

From April 1958 until March 1959 inclusive, rain water was collected in Yangambi, in standard rain-gauges, and systematically analysed for inorganic nitrogen. During the first four months, analyses were made after each separate downpour, later only once a month, the collected water being kept in stoppered bottles to which mercuric chloride had been added in order to prevent microbiological action.

Ammonia nitrogen was determined by Nessler reagent on a distillate, using ammonia-free water and 5*N* sodium hydroxide. Nitrate nitrogen was determined on the distillation residue (Devarda's alloy, distillation, Nesslerizing of the distillate) whereas nitrous nitrogen was determined colorimetrically by Griess's method. This last determination was made only during the first few months.

During the period under observation a total rainfall of 1·546 mm. was collected. This is lower than the mean total average for the area which is 1·842 mm. The total amount of nitrogen brought down by this rain amounts to 5·371 kgm. per hectare, 3·167 kgm. of it being ammonia nitrogen. Nitrous nitrogen did not exceed 3 per cent of the nitric nitrogen.

These amounts are very small, and as ammonia originates mainly in the soil itself (there are no industries near the site of collection), the net amount of inorganic nitrogen gained is of doubtful significance for agriculture and for the nitrogen balance of the arable soil.

Table 1 gives the results obtained on separate downpours during the months of May and June.

TABLE 1

Date	Rainfall (mm.)	Nitrogen p.p.m. as nitrate and nitrite	Nitrogen p.p.m. as ammonia
5–5–1958	9·2	0·07	0·50
12–5–1958	25·3	0·13	0·51
16–5–1958	17·0	0·15	0·60
21–5–1958	6·9	0·42	1·18
22–5–1958	1·1	0·56	0·78
25–5–1958	35·6	0·03	0·03
2–6–1958	20·0	0·24	0·43
6–6–1958	4·5	0·33	0·86
7–6–1958	9·7	0·12	0·39
10–6–1958	43·7	0·09	0·06
12–6–1958	3·1	0·25	0·42
21–6–1958	29·6	0·15	0·11
28–6–1958	11·6	0·20	0·18
29–6–1958	6·9	0·27	0·62

It will be noted that there is some connexion between quantity of water collected and its nitrogen content : the smaller the downpour, the higher the concentration, especially of ammonia.

During heavy downpours, the ammonia content of the rainwater decreases rapidly, reaching the detection limit after the first few millimetres. The nitrate concentration decreases also but not so rapidly.

This work was carried out independently from similar work done in Yangambi by the Division of Climatology as a contribution to the International Geophysical Year. Results of the later research, obtained in several regions of the Congo, will be published later.

J. Meyer
E. Pampfer
Division d'Agrologie, Institut National pour l'Etude Agronomique du Congo Belge,
Yangambi, Belgian Congo.
August 6.

METALLURGY

Recrystallization of Zone-Refined Lead

The decrease in recrystallization temperature with increasing purity of a metal is well known. This general phenomenon has been observed in the past few years especially in high-purity aluminium obtained by zone-refining; moreover, in France it has been demonstrated that recrystallization will occur at remarkably low temperatures. The work of Dimitrov and Albert[1,2], is representative of the recent papers on this subject; they have shown that following 97 per cent deformation at low temperatures, the recrystallization of aluminium was complete after 200 hr. at −52° C., and at least initiated after 100 hr. at −79° C. These low-temperature investigations are significant because it seems that no current theory readily explains the processes involved. Then in conjunction with other experiments on zone-refined aluminium involving recrystallization and other phenomena, they show the marked effect of small amounts of impurity.

The effect of impurity traces on the recrystallization temperature is not confined to aluminium; it will be shown here that the recrystallization temperature of lead is also considerably lowered as purity is increased by zone-refining. It has already been shown that boundary migration in zone-refined lead is very dependent upon impurities[3,4]. The same zone-refined lead was used in these experiments and had an estimated purity of 99·9999 per cent[3]; for comparison the same experiments were conducted on Tadanac brand lead of 99·999 per cent purity.

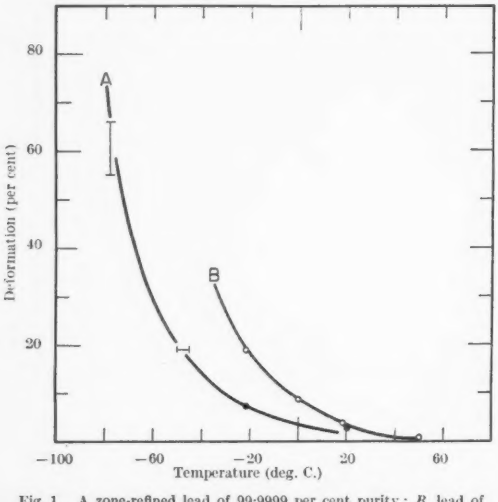

Fig. 1. A zone-refined lead of 99·9999 per cent purity; *B*, lead of 99·999 per cent purity. The strain necessary to produce complete recrystallization in 30 min. is plotted at the temperature of deformation and annealing.

For a qualitative investigation at low temperatures the procedure chosen was that of deformation and subsequent testing *in situ* at one temperature. Specimens 0·310 cm. in diameter were prepared by extrusion at room temperature through a die designed for the most uniform deformation. At a constant extrusion rate both purities of lead recrystallized during the extrusion. (It was significant that the zone-refined lead required about 20 per cent less force for extrusion than the 99·999 per cent lead.) The specimens that were used were uniform in grain size, even though grain coarsening (secondary recrystallization) occurred at room temperature. This was achieved by testing each sample soon after extrusion.

The specimens were deformed in a 'hard' Polanyi machine arranged so that the specimen and its mounting arrangement could be immersed in a liquid bath at a suitable temperature. Both the load and elongation were automatically recorded by an arrangement previously described[5], and the general procedure was as follows. At a given temperature a specimen was deformed to some predetermined strain, unloaded, and tested after some specific time. By using many specimens at each temperature it was possible to determine the strain needed for complete recrystallization after thirty minutes. The results on lead for both purities are shown in Fig. 1.

It was possible to distinguish between recovery and recrystallization in two ways. First, tests were made at varying times to determine the flow stress on a deformed specimen. Except at very short times and small softenings, the change of the flow stress with time exhibited the kinetics of recrystallization[6]. Secondly, the 'new' stress-strain curve denoting complete recrystallization exhibited such a reduced flow stress and work-hardening that it could not be attributed to recovery in a polycrystalline metal[6]. One reservation must be made for the higher temperature tests; it is not certain that secondary recrystallization rather than primary recrystallization was not the operative softening mechanism. At the lower temperatures the former process would lead to a larger grain size, while the latter would produce a finer grain size which was the case. This differentiation was not possible at room temperature or above.

Nevertheless the information presented in Fig. 1 can be considered only qualitative in nature. Recovery occurs at all temperatures in the zone-refined lead (even at 77° K. the flow stress loses its sharpness with time), and at the higher temperatures it is a competitive process. For example, even though a specimen deformed 2·9 per cent recrystallizes in 30 minutes at 20° C. it is possible to deform it a total of at least 4 per cent without recrystallization in 1 per cent stages as long as a short recovery time is allowed. Moreover, a separate investigation showed that recovery proceeded more rapidly in the presence of an applied stress. A second limiting feature is the deformation of samples at different temperatures not at one standard, low temperature.

One further item which illustrates the purity of the zone-refined lead comes from deforming large-grained specimens at 77° K. It was determined that the maximum critical resolved shear stress could not be higher than 50 gm./mm.^{2} which is less than half the

value previously reported in the literature[7]. Other deformation work is now in progress to check this point.

A recent investigation of the recovery of lead at low temperatures was made by Boesono[8] who followed the decrease of the extra resistivity at various temperatures after rolling at 90° K. The results indicate recrystallization at −100° C. after very short times with lead of 99·99 per cent purity and at −30° C. for a 'commercial' lead. Such results seem entirely possible with the large deformation available from rolling.

In comparison with the results for zone-refined aluminium it seems probable that under comparable conditions the zone-refined lead will recrystallize at lower temperatures. A comparison of the two purities of lead indicates that a change from 99·999 to 99·9999 per cent causes a decrease in the recrystallization temperature in the same test of about 30° C. These are remarkable effects to be attributed to such small impurity contents, and yet they will most likely be general for any face-centred cubic metal.

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G. F. Bolling

Westinghouse Research Laboratories,
Churchill Borough, Pittsburgh, 35

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CHEMISTRY

Droplet Circulation and Interfacial Disturbances in Gas-Liquid Systems

During recent years the process of liquid-liquid extraction has become progressively more important and the mechanism of solute transfer between liquid droplets and a second substantially immiscible liquid environment has received considerable attention. In the course of their work in this field, Lewis and Pratt[1] observed that when solute transfer, for example, acetone, occurred between hydrocarbon droplets and water, then in many cases, the droplets exhibited rapid and violent oscillations which they termed 'kicking'. Systems which exhibited this effect were found to have higher mass transfer rates than those predicted from theoretical considerations[2]. More recently the phenomenon of droplet oscillation in liquid-liquid systems has been the subject of extensive study, notably by Haydon[3] and Davies and Haydon[4]. These workers concluded that droplet oscillation was the result of the interfacial solute concentration becoming non-uniform, thereby giving rise to local interfacial tension variations which resulted in temporary droplet instability.

Similar effects have now been observed in the case of a pendant liquid droplet evaporating in air. The droplet, containing aluminium or plumbago particles, was suspended from the tip of a narrow bore tube and an optical system was used to project an enlarged image of the droplet on to a screen so that circulation patterns could be observed visually. Under these conditions, droplets of toluene, chloroform and acetone evaporating in air all exhibited vigorous internal circulation. Provided that the droplets were small, there was little evidence of the 'kicking' phenomena reported previously in the case of liquid-liquid systems although the interior of the droplet was in constant agitation. However, as the droplet size was increased, internal agitation was eventually accompanied by droplet oscillation or kicking as the breakaway point was approached.

Pendant water droplets in air showed only slight internal circulation, but the presence of a second, more volatile, component such as acetone or ammonia produced marked circulation, the degree of internal agitation increasing with the concentration of the added component. The presence of acetone in either toluene or chloroform droplets was also found to produce a similar result.

Plane gas-liquid interfaces have also been examined and again internal circulation and interfacial disturbances were noted. Thus suspended aluminium particles showed varying degrees of circulation during the free evaporation of acetone, methylated ether, benzene, toluene and ethyl acetate contained in a shallow Petri dish. Water appeared to be quiescent but, as before, the presence of acetone set up circulation patterns in the bulk liquid and, as in the case of pendant droplets, the circulation of methylated ether, benzene, toluene and ethyl acetate was also enhanced by the presence of acetone. On the other hand, if acetone or methylated ether vapour was brought near the surface of pure water, violent circulation occurred accompanied by continuous rippling of the vapour-liquid interface.

It is noteworthy that both internal circulation and interfacial rippling could be completely inhibited by traces of detergents such as 'Teepol' or by the addition of a surface film of cetyl alcohol. As might be expected, circulation also ceased when the gas-liquid system was totally enclosed so that concentration gradients in the plane of the interface were minimized and equilibrium conditions were approached.

There is no reason to suppose that these observations are specific to the systems examined and it may well be that, in many cases, mass transfer across gas-liquid interfaces is accompanied by internal liquid circulation and in extreme cases by interfacial rippling. Such considerations are of prime importance in the interpretation of absorption data and further work is necessary before the factors governing these effects are fully understood.

C. Ramshaw
J. D. Thornton

Department of Chemical Engineering,
King's College,
Newcastle upon Tyne 2.

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Number of Free Radicals in Coal During Carbonization at Different Heating Rates

During carbonization *in vacuo* at constant heating rates of 1 and 3deg. C./min. we measured the number of free radicals per gram of starting material of a vitrain with a carbon content of 86·9 per cent. This was done by means of an electron spin resonance spectrometer working at 9,000 Mc./s. The results are given in Fig. 1.

It can be seen that, when the lower heating rate is applied, the maximum increase in the number of free radicals is reached at a lower temperature than

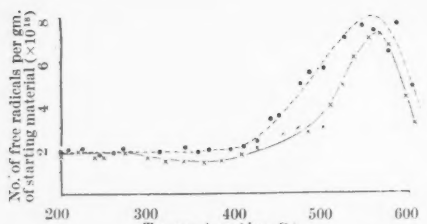

Fig. 1. Heating rate: 0———0, 1 deg. C. min.; x———x, 3 deg. C./min.

when the higher heating rate is used.

In this respect there is a close correspondence with the rate of decomposition, the maximum of which is reached at a temperature which is lower the lower the heating rate[1].

This is just another example of the relation between the electron spin resonance phenomena during carbonization, and the classical carbonization phenomena of vitrains[2].

From this experiment, and from Austen and Ingram's[3] work, it is evident that in communications about the numbers of free radicals during carbonization one should report the temperature treatment of the specimen, as this may strongly influence the number of free radicals determined.

J. Smidt
D. W. van Krevelen

Staatsmijnen in Limburg,
Central Laboratory,
Geleen, Netherlands.

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Colour Reactions of Certain Phenols with Ehrlich's Reagent

The use of Ehrlich's reagent (1 per cent *p*-dimethylaminobenzaldehyde in *N* hydrochloric acid, for the detection of indoles, pyrroles and related nitrogen-containing compounds has been a long-established analytical procedure[1,2,3]. Spraying this reagent on paper chromatograms containing indole compounds produces purple, blue, and red spots. However, certain phenols have been reported[1] to produce similar colours under the conditions of the Ehrlich test.

In the course of an investigation of the alkaline degradation products of soil humic acid, we have detected a number of highly coloured spots on paper chromatograms after spraying with Ehrlich's reagent. Flaig[4], using a degradative procedure identical to ours, obtained similar coloured areas with this reagent and concluded that soil humic acid contains indole-like moieties. Evidence from other investigations in this laboratory (to be reported elsewhere) suggested that some or all of our coloured spots correspond to phenolic compounds, instead of indole-derived compounds.

To test this assumption, we sprayed a number of naturally occurring phenols and phenolic acids with Ehrlich's reagent and with the cinnamaldehyde-hydrochloric acid reagent[2]. The results are tabulated herewith. It is apparent that compounds derived from resorcinol and phloroglucinol react with both reagents. Phloro-glucinol-derived compounds react instantly; resorcinol-derived compounds react more slowly after heating.

The chromatograms were developed in 5 per cent acetic acid-water (v/v) at 24°C. for 3·5 hr. They were air-dried, sprayed with the colour reagent, air-dried again and placed in an oven for 3 min. at 60° C.

Compounds which Produced Colours

Compound	Colour with Ehrlich's Reagent	Colour with Cinnamaldehyde Reagent	R_F
Phloroglucinol	Cherry red	Dark brown	0·63
Phloroglucinol carboxylic acid	Light pink	Light yellow-brown	0·55
2, 4, 6-trihydroxyacetophenone	Pink	Light brown	0·46
Resorcinol	Purple	Orange-brown	0·73
O-monomethylresorcinol	Purple	Light brown-purple	0·73
O-monoethylresorcinol	Light purple	Light yellow	0·66
O-monoacetylresorcinol	Purple	Light brown	0·58
Orcinol	Light rose	Yellow-brown	0·70
Pyrogallol	Pink	Orange	0·72

Compounds which did not Produce Colours

2-hydroxybenzoic acid	Homophthalic acid
3-hydroxybenzoic acid	Vanillic acid
4-hydroxybenzoic acid	Chlorogenic acid
2, 4-dihydroxybenzoic acid	Quinic acid
2, 6-dihydroxybenzoic acid	Syringic acid
3, 5-dihydroxybenzoic acid	Catechol
Gentisic acid	Toluhydroquinone
Homogentisic acid	Gallic acid

Cornelius Steelink

Department of Chemistry,
University of Arizona,
Tucson, Arizona.

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Oxidation of Ethyl Alcohol by a Mixture of Hydrogen Peroxide and Ferric Salts

It was recently found that the catalytic decomposition of hydrogen peroxide by ferric ions, and by enzymes containing haemin groups follow closely related paths[1]. This analogy can be extended to the oxidation of ethanol by a mixture of hydrogen peroxide and ferric salts. The experimental data of Walton and Christensen[2] provide evidence that ethanol is oxidized by the secondary hydrogen peroxide-ferric ion complex. A similar mechanism for peroxidase action was derived by Chance[3].

Walton and Christensen observed that the rate of oxidation of alcohol at high $[H_2O_2]/[Fe^{3+}]$ ratios becomes:

$$\frac{d[C_2H_5OH]}{dt} = k[C_2H_5OH]$$

where k is proportional to $[Fe^{3+}]_t$ (total concentration of ferric ions) and independent of $[H_2O_2]$.

Regarding the steady-state concentrations of the two intermediate complexes observed during the catalytic decomposition of hydrogen peroxide (equations X *a* and X *b* in ref. 1) it is seen that in the range where $[H_2O_2] \ll K_M + (k_3/k_4)$ (this is the case when $[H_2O_2]$ is some tenths of a mole per litre at a *p*H not exceeding 2):

$[C_I] \sim [Fe^{3+}]_t\,[H_2O_2]$, whilst $[C_{II}] \sim [Fe^{3+}]_t$.

Thus, the observed rate law can be obtained only if ethanol reacts with the secondary complex.

I am indebted to Prof. G. Stein for helpful discussion.

Mordechai L. Kremer

Weizmann Institute of Science,
Isotope Department,
Rehovoth, Israel.

July 20.

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RADIOCHEMISTRY

Autoradiography of Tritium-labelled Compounds on Paper Chromatograms

THE standard method of rendering visible radioactive compounds on paper chromatograms is to place the paper against a fast X-ray film for the requisite exposure period. The energies of β-particles emitted by tritium are so low (E_{max} = 18 keV.) that the paper itself and the inevitable air gap between paper and film absorb most, if not all, of the radiation, reducing the sensitivity of the technique below useful limits. Wilson[1] has described the preparation of scintillation autographs, in which the chromatographic strip, in close contact with a fast film, is immersed in a tank of scintillation fluid; but his method cannot be applied to the study of compounds, such as steroid hormones, which are soluble in toluene, the primary solvent of most scintillating fluids.

It seemed that a possible technique would be to coat the paper chromatogram directly with melted photographic emulsion, which would penetrate into the paper, and come into very close contact with the tritiated compound. Tritiated progesterone (Radiochemical Centre, Amersham, Code No. *TRA*-11), was chosen for preliminary tests. The chromatograms were very kindly prepared by Dr. G. H. Thomas: various amounts of labelled progesterone of known activity were spotted on Whatman No. 1 paper, and chromatographed in the Bush *A* solvent system[2]. After drying, the strips were taken to the dark-room and passed through a trough of melted photographic emulsion at 50° C. To facilitate subsequent handling, the strips were next fixed to hangers of the type used for holding X-ray films. They were hung up at room temperature for 2 hr. to allow excess emulsion to drip off, and the remaining emulsion to dry; then placed in a light-proof box with about 20 gm. of dried silica gel, and left in a cold room at 5° C. for periods ranging from 1 to 4 weeks. They were finally processed in tanks of standard X-ray developer and fixer, washed for 2 hr. in running water, and dried.

Ilford *K*2 emulsion is very satisfactory for this work. It is a nuclear research emulsion of reduced sensitivity, suitable for recording low-energy electrons, and having a low background level of developed silver grains in areas unaffected by radioactivity. Coating the strips is simplified if the emulsion is diluted in the trough by an equal volume of distilled water: this does not appear to affect the properties of the emulsion, and gives a thin uniform spread over the paper. Strips prepared with diluted emulsion in this way need 5–6 min. in developer, and 10–15 min. in fixer. Undiluted emulsion gives a thicker and sometimes uneven coverage, and needs longer development and fixation. In neither case are the spots noticeably smeared by immersion in the emulsion.

Many levels of activity have now been tried, and those activities from 0·1 μc. of tritiated progesterone up to 5 μc. have consistently produced black spots of developed silver, readily visible, and increasing in density with increasing activity. With undiluted emulsion and four weeks exposure, 0·07 μc. has been visualized and 0·01 μc. has on one occasion given a recognizable spot. Control chromatograms with unlabelled progesterone did not produce any blackening of the emulsion.

At the specific activity being used, the spots of 0·1 μc. represent about 0·15 μgm. of progesterone. The technique is obviously very sensitive, and as more tritiated compounds become available at high specific activities, it would seem to have many possible applications.

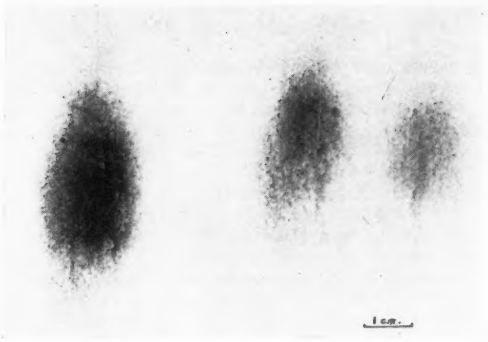

Fig. 1. Portion of chromatogram covered with diluted *K*2 emulsion showing from left to right, 3·3 μc., 0·66 μc., and 0·33 μc., respectively of tritiated progesterone, after 2 weeks exposure.

A. W. ROGERS

Department of Anatomy,
University of Birmingham.

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PHYSIOLOGY and BIOCHEMISTRY

Effect of Diet on the Blood Sugar and Liver Glycogen Level of Normal and Adrenalectomized Mice

WHILE investigating the effects of adrenal steroids on the blood sugar and liver glycogen levels of mice we were uncertain whether the previous diet of the mice affected these levels. Different types of food were therefore fed to groups of normal and adrenalectomized mice after which the blood sugar and liver glycogen levels were estimated.

Male white mice of the Swiss strain (15–20 gm.) obtained from the Agricultural Research Council were adrenalectomized under ether anæsthesia. On the morning of the second post-operative day the adrenalectomized animals together with groups of normal (non-adrenalectomized) mice were fasted for 24 hr. to deplete the liver of glycogen and lower the blood sugar to a resting level. During this time they had free access to drink; water for the normal mice and saline for those that had been adrenalectomized. Groups of ten mice were used. At the end of the fasting period one group of normal and one group of adrenalectomized mice were killed and used as controls and the remainder given their special diet *ad lib.*

Three types of food were used: (1) a cube diet (M.R.C.41 *b*); (2) pure glucose and (3) pure protein (casein). The groups of mice were killed at logarithmic time intervals and the biochemical estimations made. The blood sugar levels were measured by the method of Hagedorn and Jensen and the liver glycogen by that of Block and D'Arcy[1]. The effect of one of these diets (cubes) is shown in Fig. 1. Both the blood sugar and the liver glycogen content rise rapidly reaching a peak value after 8–16 hr. They then fall to a lower level. The result of the glucose diet is similar except that the peak blood sugar levels are reached in only one hour. Both the glycogen and blood sugar peaks are almost identical quantitatively with those obtained with a cube diet. The effects produced by the pure protein

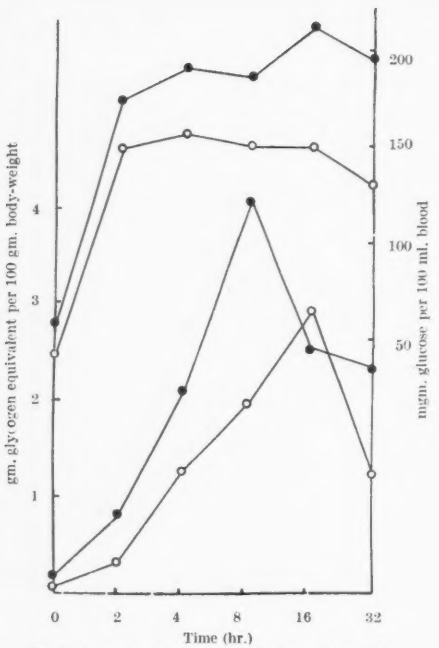

Fig. 1. ○——○, adrenalectomized; ●——●, normal.

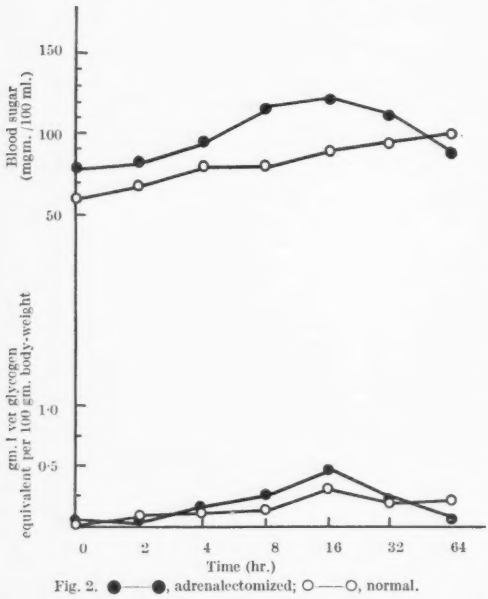

Fig. 2. ●——●, adrenalectomized; ○——○, normal.

diet, however, are quite different from the other two (Fig. 2). The highest liver glycogen level reached was only 300 mgm. per 100 gm. mouse and the blood sugar peak was 120 mgm. per cent.

Throughout these experiments there appeared to be no significant differences between the responses given by normal mice and those which had been adrenalectomized.

We conclude from this investigation that a diet of pure protein fed to normal and adrenalectomized fasted mice causes only a slight rise in both liver glycogen and blood sugar. Moreover, the possession of adrenal glands does not influence the ability of the mice to raise the sugar content of their blood or deposit glycogen in the liver, irrespective of the diet on which they are fed.

A more detailed report of this work is being prepared and will be submitted elsewhere.

B. P. Block
G. S. Cox

Department of Pharmacology,
School of Pharmacy,
29–39 Brunswick Square,
London, W.C.1.

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Influence of Sulphur Dioxide Inhalation on the Phagocytic Activity of the Macrophage System

Following recent reports on the effect of 'smog'[1], and of the increasing incidence of air pollution in industrial and urban areas[2], we have been prompted to investigate the activity of the macrophage system following inhalation of an atmosphere contaminated with sulphur dioxide. The choice of this gas was made due to its predominance in air-pollution, and to its ability to cause immediate and obvious reactions on the respiratory tract[3].

The present experiment was carried out on 160 male white mice (Swiss strain) of 20—30 gm. body-weight. The animals were divided into groups of eight and exposed to varying concentrations of sulphur dioxide for single periods of 5 min.—4 hr. The phagocytic activity was measured at intervals by the particulate carbon method[4]. Each animal was given one intravenous injection of carbon of particle size 250A., the dose of carbon being calculated on the basis of 16 mgm. per 100 gm. body-weight. Blood was taken at short intervals during the first 60 min. following the injection, and the concentration of carbon in each blood sample was measured by means of an absorptiometer. The logarithmic values of the absorptiometer readings lie along a straight line when plotted against time, and the slope of this line has been taken as a measure of total body phagocytic activity or the phagocytic index, here denoted by the symbol K. Immediately following the phagocytic assessment the animals were killed and specimens of liver, spleen and lung were fixed in buffered formalin and sections cut 8 μ thick and stained with dilute eosin.

24 of the animals were used as controls. These received no previous treatment and were not exposed to the noxious gas. An average phagocytic index or K value of 19 ± 8 was obtained.

The remainder of the mice were exposed to atmospheres containing concentration of sulphur dioxide ranging from 3 (1·05 p.p.m.) to 824 mgm. (288 p.p.m.) per cu.m. Each group of eight mice was kept in a stainless-steel wire cage, which was placed in a one cu.m. all-glass exposure chamber. Sulphur dioxide gas was metered into the chamber and circulated by means of a fan. The temperature of the compartment was maintained at around 25° C. and excess moisture removed by calcium chloride. Samples of the air contained in the chamber were collected at intervals and the concentration of the sulphur dioxide gas was estimated.

Table 1 shows the relative K values obtained from mice exposed to an atmosphere containing sulphur

Table 1. Effect of Inhalation of Sulphur Dioxide Gas on the Phagocytic Activity of the Macrophage System.

Group identity	Number of exposures	Duration of each exposure	Range of concentration of sulphur dioxide gas per cu. m.	Time following exposure of phagocytic assessment	Phagocytic index (K value)
1—5	1	5-25 min.	up to 824 mgm.	immediately	23 ± 12
6—10	1	5-25 min.	up to 824 mgm.	30 min.	22 ± 6
11	1	4 hours	10-117 mgm.	1 hour	16 ± 2
12—17	5 (each a week apart)	4 hours	3-224 mgm.	24 hours to 6 days	56 ± 22
controls	nil	—	—	—	19 ± 8

dioxide gas. The results indicate that there was very little change in phagocytic activity in those animals which underwent a single or 'acute' exposure. However, when the animals were exposed weekly for durations of four hours over a period of five weeks, there was an increase of phagocytic activity from the control K value of 19 ± 8 to a value of 56 ± 22. This increase was maintained for at least one week following the final exposure. The sections of liver and spleen confirmed that the main uptake of carbon had been made by the macrophage elements of those organs. The lung sections, although indicating acute and chronic inflammatory changes, showed no significant increase of carbon-containing macrophages either associated with the alveoli or in the bronchial tree. The spleen section showed a slight increase of the normal carbon uptake together with a heavy and generalized deposition of hæmosiderin.

According to Nicol and Bilbey[5] the macrophages of the liver and spleen become mobilized and migrate to the lungs, where they are eliminated by way of the bronchial tree. It was therefore reasonable to suppose that such macrophages would be directly influenced by the inhalation of an irritant gas, and that there may be a secondary effect on the fixed macrophage cells in the liver and spleen. The results have indicated that the inhalation of air containing sulphur dioxide has little or no effect on the phagocytic activity of the macrophage system when the subject is exposed to the gas on a single occasion. However, when the exposure is repeated so as to give rise to 'chronic' irritation, there is a significant increase in the phagocytic activity which is raised from $K19$ to $K56$. From the microscopical appearances this increased phagocytic activity occurs in the liver and the spleen, and there is little or no increase in the macrophage component of the lungs.

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D. L. J. Bilbey
H. Salem

Department of Anatomy
and Department of Pharmacology,
University of Toronto,
Canada.

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Accumulation of Dextran in Human Red Cells after Hæmolysis

Mild osmotic hæmolysis induces changes in the porosity of red cells, which seem to be largely reversible. It has been reported that ghosts can function as osmometers[1] and that the kinetics of glycerol penetration may be unaltered by hæmolysis[2]. Hæmolysis has been used to introduce metabolically active substances into the ghosts[3]. The influx of 'foreign' hæmoglobin as a result of hæmolysis has also been reported[4,5].

It appears that the accumulation which occurs as a result of hæmolysis resists subsequent washing of the cells. This may be interpreted as probably indicating the entry of a normally non-penetrating substance during hæmolysis, when the porosity is at least manifestly adequate to allow the escape of hæmoglobin molecules, with a subsequent restoration of the permeability restrictions to approximately the same as in an unhæmolysed cell.

The aim of the experiments reported here has been both to determine the magnitude of such an accumulation and also to find evidence of a molecular sieving effect if penetration of solutes across the cell membrane occurs.

Dextran has been used as the test substance because it is polydisperse and non-ionic, and also because it reduces the hæmoglobin loss in hypotonic hæmolysis[6]. The pattern of hæmolysis was markedly altered, only in a small proportion of the cells did the residual hæmoglobin concentration approach equality with that in the suspending medium[7]. After hæmolysis in a 7·5 per cent dextran fraction for example the mean residual cell hæmoglobin is about 50 per cent of the original value[6].

The procedure was as follows.

Packed human red cells previously washed three times were suspended in a 7·5 per cent solution of a dextran fraction (Pharmacia, FDR-172-IV, $[\eta] = 0{\cdot}239$, $\overline{M}_n = 32000$, $\overline{M}_w = 55000$) in distilled water in the volume ratio 1 : 9. After incubation at 5° C. for 13½ hr. approximate isotonicity was restored and then the dextran treated partially hæmolysed cells were washed up to 4 times in isotonic Krebs-Ringer phosphate (pH = 7·4). After each of the three last washings the supernatant and a cell sample were taken for dextran analysis. The absence of cells in the supernatant was checked with a phase contrast microscope. Red cells suspended in an isotonic Krebs-Ringer phosphate—dextran solution served as controls.

Total dextran was estimated by a modified anthrone method and the differential molecular weight distribution curves were determined turbidimetrically after fractional precipitation with ethanol[8]. Hæmoglobin was estimated as the carboxy-derivative at 568 mμ. The hæmatocrit volumes were determined after centrifugation at 9600 g for 6 min.

24·2 mgm. ml. of dextran, that is, approximately one-third of the original concentration in the suspending medium (75 mgm. ml.) was found associated with the cell fraction, and remained constant throughout the last three washes (no estimations were made until after the second wash). The volume of the partially hæmolysed cells was slightly less than the original volume, while after re-suspension in an isotonic medium and removal of supernatant dextran there was considerable shrinkage to about half the original volume. The concentration of the accumulated dextran has been expressed in terms of the original cell volume. The dextran associated with the cell fraction also had a different molecular size distribution contain-

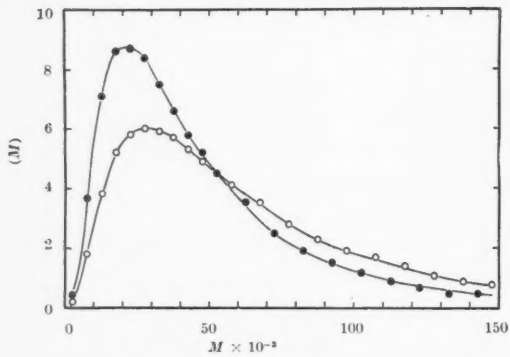

Fig. 1. Differential molecular weight distributions of original dextran (○——○——○) and dextran accumulated in cell fraction (●——●——●)

ing a higher proportion of smaller molecules than the original dextran in which the cells were suspended (Fig. 1). No accumulation was found in the controls. The mean residual hæmoglobin in the cells was 49 per cent of the original value. All the hæmoglobin liberation occurs in the dextran solution shortly after introduction of the cells, after which it remains constant[6]. There is no further hæmoglobin loss during washing.

The number of dextran molecules accumulated per red cell can be estimated approximately. The number and weight averages ($\overline{M}_n$, $\overline{M}_w$) of the accumulated dextran were not measured directly but were calculated approximately as 29,000 and 47,000 respectively from the smoothed distribution curve which was assumed to be log-normal and of a Lansing-Kraemer type. In the case of the original fraction the Lansing-Kraemer distribution, calculated from the $\overline{M}_n$ and $\overline{M}_w$ values which were available, fitted the turbidimetrically determined distribution rather well. For dextran molecules assumed to be hydrodynamic spheres with a weight average of 47,000, the Einstein-Stokes radius (R_{ES}) has been estimated to be about 50 A[8]. Assuming also a mean red cell volume of 87 μ^3 the mean number of dextran molecules per cell has been calculated as $4{\cdot}3 \times 10^7$. If these all lay outside the cell surface tightly packed there would be 21 concentric layers of dextran molecules (surface area of red cell = 163 μ^2).

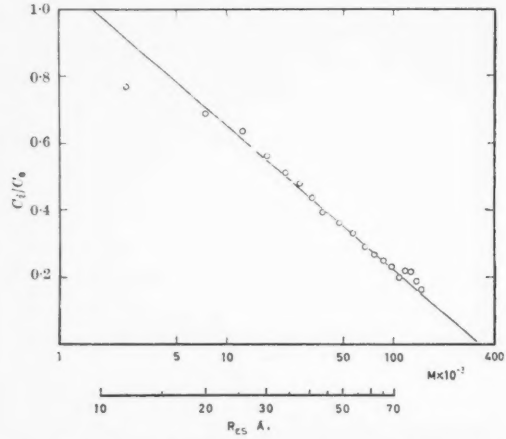

Fig. 2. Partition of dextran as a function of molecular weight. The straight line was drawn by eye. C_f concentration of dextran in cell fraction; C_0 concentration of dextran in which the cells were originally suspended; M molecular weight. R_{ES} Einstein-Stokes radius.

Dextran was not found associated with non-hæmolysed cells, but using dextran labelled with carbon-14 the uptake of $2{\cdot}4 - 8{\cdot}6 \times 10^3$ molecules per cell has been reported[9]. Such a quantity would probably not be detected chemically and comparison with our figures gives a value of 10^4 for the ratio of the uptake between hæmolysed and non-hæmolysed cells.

The quantity associated with hæmolysed cells ($4{\cdot}3 \times 10^7$ molecules) is about 1/3 of the number of hæmoglobin molecules remaining after partial hæmolysis in 7·5 per cent dextran and the solvated volume of these dextran molescules is about 23 μ^3, for example, 25 per cent of the original volume of the cell.

The partition (C_f/C_0) has been plotted as a function of molecular weight in Fig. 2. These may not be true partition coefficients because there may be a time factor which limits the amount accumulating. For example the transient existence of larger 'pores' to allow hæmoglobin escape probably lasts for less than a minute and possibly for only a few seconds[10,11].

If accumulation occurs only during this time then the limited period available may well lead to partition values which are lower than those which would be obtained if a steady state existed. Extrapolation of the line in Fig. 2 indicates that non-penetrability lies above about 300,000 (R_{ES} = 100 A.). It must however be noted that estimations in the region of the extremes of the molecular distributions cannot be regarded as reliable and a cut off may in fact exist for higher molecular weights. It is however not improbable that the porosity is heterogeneous and relatively greater for non-ionic molecules, so that dextran molecules considerably larger than hæmoglobin might be expected to penetrate. Further work is required to characterize this phenomenon more precisely.

It is concluded that the magnitude of the dextran accumulation together with the molecular sieving observed constitute strong evidence that the major part at least of the dextran taken up has penetrated into the red cell during hæmolysis when a great transient increase in the porosity occurs. These experiments will be reported in detail in *Acta Physiologica Scandinavica*.

We wish to thank Dr. G. Wallenius who kindly made the turbidimetric measurements, Pharmacia Ltd. who supplied the dextran fraction, and the Swedish Medical Research Council and the University of Uppsala for financial support.

N. V. B. Marsden
S. G. Östling

Institute of Physiology,
University of Uppsala,

June 4.

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Excitability and Phosphorylation of Muscle and Nerve in Sodium-free Hydrazinium Solution

THE electrical activity of frog skeletal muscle was found to be maintained in a sodium-free hydrazinium solution[1,2]. In addition, excitability of ventral nerve roots was normal in a hydrazinium solution (unpublished). A series of studies were undertaken to determine the influence of hydrazine on the biochemical properties of conductive tissues, and this communication is concerned specifically with phosphorylation and energy synthesis.

Sartorius muscles from *Rana pipiens* were immersed in sodium-free sucrose solution containing 224 m*M* sucrose, 1·8 m*M* calcium chloride, and 2 m*M* potassium chloride, for 30 minutes in order to eliminate the electrical activity, and then in the sodium-free hydrazinium solution consisting of 112 m*M* hydrazine, 1·8 m*M* calcium chloride and 2 m*M* potassium chloride adjusted to *p*H 6·5. The value of the resting potential of the muscle fibres was approximately 90 mV. immediately after immersion in hydrazinium solution, and tended to drop gradually to approximately 80 mV. within 2 hours[1,2]. No further reduction of the resting potential, however, was observed after immersion for 5 hours at room temperature (27°C.), nor was excitability in any way abnormal during this period. The tenth and eleventh ventral roots of bullfrogs were treated in a similar manner. Again, the electrical activity of the ventral roots vanished after incubation in sucrose for 2 hours, but promptly returned to normal after immersion in a hydrazinium solution and was maintained for at least 5 hours.

The effect of 2,4-dinitrophenol on the electrical activity of muscles or nerves was found to be extremely remarkable in sodium-free hydrazinium solution as compared to normal Ringer. When the muscles were soaked in hydrazine containing 0·1 m*M* dinitrophenol the resting potential dropped from 85–90 mV. to 70–75 mV. while the action potentials disappeared within 30 minutes. When these preparations were re-immersed in normal Ringer, the resting and action potentials were again normal. In Ringer this concentration of dinitrophenol had no marked effect on the resting and action potentials, although the muscle showed a slight contraction. Similar effects were noted at a concentration of 0·01 m*M*. At a concentration of 0·05 *M* the excitability of the nerve roots was completely, but reversibly, eliminated in a hydrazinium solution and unaffected in Ringer.

After the muscles or nerves were immersed in sucrose, they were incubated at 27°C. in 5 ml. of various solutions for 1 hour and then for an additional hour in the presence of 50 μc. of carrier-free orthophosphate-^{32}P. Dinitrophenol was added 30 minutes before orthophosphate-^{32}P. Preparation and factionation of the tissue extracts by means of a 'Dowex-1' anion exchange resin was according to methods described elsewhere. Chemical analyses were performed on 8 nerve roots, with a total weight of 47–56 mgm.; and 2 muscles with a combined weight of 120–150 mgm. Measurement of radioactivity was done with a conventional Geiger tube and scaler; and counted with a probable error of 3 per cent.

Replacement of hydrazine for sodium in the external medium resulted in a considerable decrease in the specific activity (c.p.m./m.mole phosphorus or nucleotide) of orthophosphate, adenosinetriphosphate and phosphocreatine of either muscle or nerve. Choline substitution for sodium led to a comparable decrease in the specific activity of the organic phosphates without appreciably affecting orthophosphate. Dinitrophenol produced only a slight decrease in the specific activity of the phosphates, either in the sodium or hydrazine systems.

In general, the decrease in the total phosphocreatine of both muscle and nerve paralleled the decrease in specific activity of the organic phosphates. Substitution of hydrazine for sodium resulted in a complete loss of phosphocreatine, while in choline-Ringer the decrease was over 85 per cent. The presence of dinitrophenol in Ringer was without effect on phosphocreatine.

The ability of frog conductive tissues to exhibit normal electrical activity in the presence of such an inhibiting ion as hydrazine was unexpected. Preliminary findings with isolated rat brain mitochondria indicate that a concentration of 100 m*M* almost completely inhibited both oxidative and phosphorylative metabolism. Complete replacement of sodium with hydrazine often resulted in almost total depletion of the phosphocreatine, and frequently the muscles were in contracture despite normal electrical properties. The actual concentration of adenosine triphosphate, however, does not seem to decrease to as great an extent as phosphocreatine, despite its diminished turn-over in the presence of hydrazine. Whatever the possible role of hydrazine, the present findings clearly demonstrate that normal excitability is maintained in conductive tissues where the energetic machinery is almost completely inhibited. For the present, there is no explanation for the complete inhibition of excitability by dinitrophenol in the hydrazinium solution. It should be pointed out, however, that hydrazine is not acting directly on phosphorylation in the sense of dinitrophenol, but is

Table 1. SPECIFIC ACTIVITY OF VARIOUS ORGANOPHOSPHATES OF FROG SARTORIUS MUSCLE AND VENTRAL ROOTS IN VARIOUS SOLUTIONS
EACH VALUE IS THE RESULT OF THREE SEPARATE EXPERIMENTS AGREEING WITHIN 8 PER CENT.

Experiment	Ortho-phosphate		Phospho-creatine		Adenosine triphosphate		Adenosine diphosphate		Diphospho-pyridine nucleotide		Total phospho-creatine*
	S.a.	% change	S.a.	% change	S.a.	% change	S.a.	% change	S.a.	% change	
Muscle :											
Ringer	71	—	30	—	31	—	4·1	—	1·6	—	1·75
Hydrazine	29	−59	6·2	−79	7·1	−67	0·9	−68	0·4	−75	0·0
Ringers + DNP (0·01m*M*)	68	− 5	26	−14	27	−13	3·6	−13	1·5	− 7	1·86
Hydrazine + DNP	27	−64	5·8	−81	7·5	−76	1·0	−75	0·4	−75	0·0
Choline	60	−15	12	−60	9·0	−71	1·5	−64	1·3	−18	0·20
Nerve :											
Ringer	45	—	22	—	20	—	3·2	—	0·6	—	1·80
Ringer + DNP (0·05m*M*)	43	− 4	21	− 4	18	10	3·3	+ 3	0·6	0	1·75
Hydrazine	40	−11	4	−90	5	−75	2·0	−63	0·2	−66	0·3
Hydrazine + DNP	38	−18	4	−90	4	−80	2·0	−63	0·3	−50	0·2

S.a. = c.p.m./m.moles phosphate (orthophosphate and phosphocreatine) or nucleotide (and others).
* Phosphocreatine values are in μ moles/gm. tissue.

probably combining with ketones and aldehydes involved in glycolysis and the tricarboxylic acid cycle (unpublished). Such observations do not lend support to the concept of a 'sodium pump', but rather corroborate the thesis that phosphorylative mechanisms are not activated during conduction[3,4]. Furthermore, it would appear that phosphocreatine is not at all essential for the maintenance of either the membrane[5] or action potential.

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L. G. Abood
K. Koketsu
Departments of Psychiatry and Biochemistry,
University of Illinois College of Medicine,
Chicago 12.
June 15.

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Increase in the γ-Aminobutyric Acid Content of Rat Brain After Ingestion of Ethanol

γ-Aminobutyric acid is present in relatively large amounts in the mammalian central nervous system, where it exists chiefly in the free form [1,2]. The formation of this amino-acid in brain tissue takes place by the decarboxylation of L-glutamic acid [1,3,4]. There are in the literature several reports of a number of substances, mainly hydrazides, which lower the central nervous system level of γ-aminobutyric acid. In addition, a few substances, like diphenylhydantion and acetazoleamide, and some conditions have been reported to elevate the brain γ-aminobutyric acid content [5].

We have observed that ethanol adminstration to the rats caused an increase in the brain γ-aminobutyric acid during the period of intoxication. To four groups of rats of the Wistar strain (7 and 8 animals), previously fasted for 24 hr. was given by means of a stomach tube 430 mgm. of ethanol per 100 gm. of body-weight as a 33 per cent solution. Six rats received the same quantity of ethanol and 167 mgm. of L-glutamine per 100 gm., and to 4 rats was given only the same amount of glutamine as water solution. Three control rats received an equal quantity of water. The control animals were killed immediately and the others at various times up to 24 hr. The brains were excised quickly and homogenized in 75 per cent ethanol. The concentrated brain extracts were then studied chromatographically according to a modified method of Roberts and Frankel [1].

The γ-aminobutyric acid content of whole brain of the control rats was 44 mgm. (range 42·5–45 mgm.) per 100 gm. of fresh tissue. The results of the experiments with the 2 series of rats that received ethanol only are combined in Fig. 1. The maximum elevation of γ-aminobutyric acid, a 34 per cent increase of the initial value, occurred at 60 min. after administration of alcohol. The γ-aminobutyric acid-level of the rats that received ethanol and glutamine or only glutamine (Fig. 2) also rose; but the maximum increase at 40 min. was only 18 and 20 per cent of the initial value, respectively.

The observation that ethanol ingestion increases

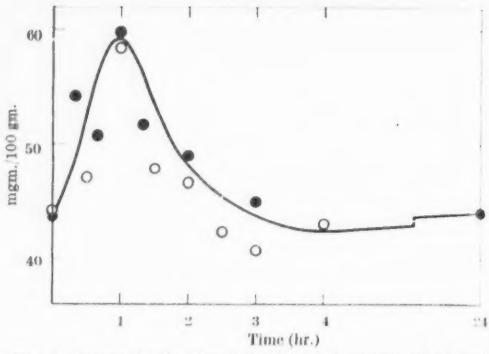

Fig. 1. Change in the γ-aminobutyric acid content of rat brain after ethanol administration. Black and white circles represent two different series of experiments.

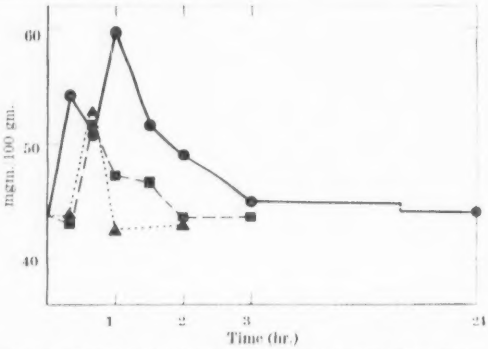

Fig. 2. Change in the γ-aminobutyric acid content of rat brain after administration of the following substances: ●, ethanol only; ■, ethanol and L-glutamine; ▲, L-glutamine.

the γ-aminobutyric acid content of brain is in agreement with the conception presented elsewhere[3] that brain γ-aminobutyric acid content varies inversely with brain excitability.

H-M. Häkkinen
E. Kulonen
Research Laboratories of the State Alcohol Monopoly,
Helsinki. June 3.

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Sex Difference in Ethanol Tolerance of Rats

In experiments on factors which influence the behaviour of rats in a simple functional test during alcohol intoxication, it was observed that after identical treatment the performance of young, sexually mature females was less impaired than was the performance of males. In testing, a record is made of the sliding angle on a tilted plane with a rough surface. The sliding angle is a linear function of alcohol dose in the approximate range of 0–8 mgm. ethanol/gm. body-weight, orally administered. A full description of the test has been given elsewhere.[1]

Rats from the laboratory supply were fasted overnight, 2 mgm. ethanol/gm. body-weight was injected intraperitoneally as a 10 per cent (w/v) solution in saline, and testing was carried out with 15-min. intervals until 90 min. after injection. When blood alcohol was determined, samples were drawn

Table 1. PERFORMANCE OF RATS IN TILTED PLANE TEST DURING ETHANOL INTOXICATION

Exp. series	Number of animals		Age of animals, weeks		Performance in test		Sexes different, $P <$	Blood alcohol (mgm.%)	
	M	F	M	F	M	F		M	F
I	10	15	20	14	66·9±4·8	74·7±6·1	0·005	202±11	207±16
II	10	10	15	11	68·7±5·9	68·7±5·3	NS	202±11	196±14
III	14	14	14	14	68·8±6·0	75·7±5·1	0·001		
	14	14	18	18	64·2±5·0	69·3±4·4	0·01	210±16	206±14
	14	14	22	22	62·0±1·9	63·2±4·1	NS		

The results expressed as per cent of an initial 'sober' value obtained immediately before alcohol injection. The lowest value observed in 6 tests during 90 min. following injection is given. Standard deviation is indicated. In series III, the same individuals were tested at three different ages. The means from all 6 tests in one experimental run gave comparable results.

from the tail, immediately after the final testing, for analysis according to the method of Newman and Newman[2], modified to allow the use of approximately 100 mgm. of blood. The results are shown in Table 1. The performance of the animals indicates that the tolerance of females increases transiently when breeding maturity is reached. It returns to the same level as that of the males in about 8 weeks.

The higher tolerance of the females is not due to differences in rate of alcohol oxidation, since no significant difference in blood alcohol level was found. Ijiri[3] observed that a 1 per cent alcohol solution increased *in vitro* oxygen consumption of unstimulated cerebral cortex and mid-brain tissue from normal rats, whereas even a 0·5 per cent solution depressed the oxygen consumption of corresponding tissues from castrated animals. Goldberg and Stortebecker[4] have reported an anti-narcotic effect of oestrone on alcohol intoxication in castrated female rabbits and conclude that the resistance of the central nervous system is related to the hormonal state. Angelucci[5] has demonstrated a sex difference in rats with respect to morphine tolerance, females being more resistant than males. Female rats tolerate chlorpromazine better than do male rats, and the tolerance of males is reduced with advancing age.[6]

The present observation has obvious relevance for the selection of animals for experiments on the effects of alcohol. Whether a change in the general response to stressors or some specifically nervous mechanism is involved cannot be judged on basis of this material.

HENRIK WALLGREN
Research Laboratories, State Alcohol Monopoly,
Helsinki, Finland. June 3.

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α-Ketoglutaric Acid and Pyruvic Acid in Blood, Cerebrospinal Fluid and Urine

DETERMINATIONS of α-ketoglutaric acid and pyruvic acid in blood, cerebrospinal fluid and urine have been carried out using 2, 4-dinitrophenylhydrazone method.[1] The keto-acid hydrazones were separated, either by paper electrophoresis or by paper chromatography.

The electrophoretic separation[2] was carried out in 0·05 *M* sodium bicarbonate at 400–420 V./10–18 m.amp. for 3 hr. on Whatman No. 1 paper (20 × 29 cm.). The chromatographic separation[3] was performed in *n*-butanol-ethanol-1 per cent ammonia mixture (6 : 1 : 3 v/v). The amount of hydrazones applied at the start corresponded to 0·5 ml. of blood or urine respectively, or to 1 ml. of cerebrospinal fluid. After separation the hydrazone spots (both isomers in the case of pyruvic acid) were extracted with 1 *N* sodium carbonate and measured at 380 mμ on the Zeiss spectrophotometer.

Higher values of pyruvic acid in electrophoretic separation (Table 1) are due to the fact that together with pyruvic acid other α-keto-acids (eventually aldehydic acids) found in traces only in the biological material, are determined and their hydrazones travel in the electric field with the same speed as hydrazone of pyruvic acid does. As it was formerly shown in the case of pyruvic acid hydrazone, approximately the same mobility was observed for hydrazone of glyoxylic acid and phenylpyruvic acid (two isomers again), and for α-ketoisocaproic acid by Biserte and Dassonville.[4] Both hydrazones mentioned above can be separated by chromatography.

Table 1. VALUES OF α-KETOGLUTARIC ACID AND PYRUVIC ACID IN BLOOD AND CEREBROSPINAL FLUID AS DETERMINED BY ELECTROPHORETIC AND CHROMATOGRAPHIC METHODS

	The number of cases	Chromatographically mgm./100 ml.		Electrophoretically mgm./100 ml.	
		alpha keto-glutaric acid	pyruvic acid	alpha keto-glutaric acid	pyruvic acid
Blood	12	0·15±0·07	0·41±0·11	0·14±0·08	0·50±0·14
Cerebro-spinal fluid	6	not exceeding 0·04	0·48±0·12	not exceeding 0·04	0·54±0·14

In urine of 10 patients confined to bed and suffering from no metabolic disease 14·13±3·20 mgm. of α-ketoglutaric acid and 8·16±1·55 mgm. of pyruvic acid were found on average during 24 hr. Five employees of this institute carrying out their normal duties excreted 18·40±4·05 mgm. of α-ketoglutaric acid and 11·06±4·84 mgm. of pyruvic acid in 24 hr. Both physical and mental strain increase the amount of α-keto-acids eliminated in the urine.

Patients confined to bed excreted maximum values of keto-acids during the afternoon or evening hours. Women eliminated more α-keto-glutaric acid during the night than men.[5]

E. ZELNICEK
Department of Medical Chemistry,
Masaryk University,
Brno, Czechoslovakia. May 3.

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Effects of Methylthiouracil or Thyroidectomy on Activation of Pituitary Acid Phosphatases *in vitro* by Whole Hypothalamic Extract

In earlier experiments[1] it was shown that incubation of whole rat pituitaries *in vitro* in whole aqueous hypothalamic extract increased pituitary acid phosphatase activity. In further experiments[2-5] evidence has been submitted in support of the view that a relationship exists between activation of pituitary acid phosphatases *in vivo* and formation of the thyreotrophic hormone and that the presumed hypothalamic humoral factor activating pituitary acid phosphatases *in vitro* is related to thyroid-stimulating hormone secretion. The present communication gives the results of experiments investigating the extent to which the influence of hypothalmic extract on acid phosphatases in the rat pituitary *in vitro* can be modified by previous administration of methylthiouracil to hypothalamus donor rats or by previous thyroidectomy of these animals.

In the first experiment 40 fresh pituitaries from albino rats (descendants of the Wistar strain) were divided into five groups and incubated for one hour at 37 ± 0·1° C. in the following media: (1) Krebs-Ringer phosphate with 300 mgm. per cent glucose; (2) the same medium plus extract from 2/3 of one control rat hypothalamus/c.c.; (3) the same amount of hypothalamic extract from rats to which 0·2 per cent methylthiouracil was administered in food 16 days before they were killed; (4) hypothalamic extract from rats to which 0·5 per cent dried thyroid ('Thyreoidin' SPOFA) was administered in food for a period of nine days before they were killed; (5) hypothalamic extract from rats to which both methylthiouracil and dried thyroid were administered. The results of biochemical determination of acid phosphatase activity in the individual groups of pituitaries are given in Table 1.

Table 1.

Group	1 medium only	2 control hypothal.	3 hypothal. methyl thiouracil	4 hypothal. 'Thyreoidin'	5 hypothal. methyl thiouracil + Thyreoidin'
No. of pituitaries	8	8	8	8	8
Mean weight of pituitaries (mgm.)	8·5	8·2	8·1	7·1	6·6
mgm. of hypothalamic tissue/c.c. incubations medium	0	100	110	95	90
Mean activity of acid phosphatase in the pituitaries K.A.U./gm. $\pm\sigma_M$	1·56 ± 0·162	2·30 ± 0·078	1·51 ± 0·111	2·40 ± 0·214	2·69 ± 0·175

Comparison of individual groups in *t*-test: 2:3 = $P > 0{\cdot}01$; 2:5 = $P = 0{\cdot}05$-$0{\cdot}02$.

In the second experiment 40 fresh rat pituitaries were again divided into five groups and incubated in the following media: (1) Krebs-Ringer phosphate with 300 mgm. per cent glucose; (2) extract of 2/3 control rat hypothalamus/c.c.; (3) hypothalamic extract from rats subjected 12 days previously to thyroidectomy; (4) hypothalamic extract from rats to which 0·5 per cent dried thyroid was administered in food for 12 days before they were killed; (5) hypothalamic extract from rats subjected to both treatments (thyroidectomy + 'Thyreoidin'). The results of the determination of acid phosphatase activity are given in Table 2.

Table 2.

Group	1 medium only	2 control hypothal.	3 hypothal. thyroidect.	4 hypothal. 'Thyreoidin'	5 hypothal. thyroidect. + 'Thyreoidin'
No. of pituitaries	8	8	8	8	8
Mean weight of pituitaries (mgm.)	5·7	5·2	5·8	5·4	5·4
Mgm. of hypothalamic tissue/cc. incubations medium	0	100	100	95	100
Mean activity of acid phosphatase in the pituitaries K.A.U./gm. $\pm\sigma_M$	1·95 ± 0·138	2·93 ± 0·205	2·11 ± 0·279	2·67 ± 0·259	2·69 ± 0·121

Comparison of groups No. 2 and 3 in *t*-test = $P = 0{\cdot}02$.

The results show that: (1) incubation in control hypothalamic extract increases pituitary acid phosphatase activity *in vitro*; (2) previous administration of methylthiouracil to hypothalamus donor rats or previous thyroidectomy of these animals inhibits this increase; (3) the administration of dried thyroid alone does not affect activity under the given conditions; (4) the administration of dried thyroid counteracts the inhibition of activation observed after methylthiouracil or thyroidectomy alone. In our view the above findings are evidence of the existence of a hypothalamic humoral factor activating simultaneously pituitary acid phosphatases and thyroid-stimulating hormone secretion. The decrease which occurs in the concentration of this factor in the hypothalamus after methylthiouracil or thyroidectomy could be due to its being washed out to portal system to increase thyroid-stimulating hormone secretion. The administration of dried thyroid caused no marked change in the activating effect of hypothalamic extract; in other experiments[4], however, more prolonged administration of dried thyroid slightly enhanced its effect.

V. Schreiber
V. Kmentova

Third Medical Clinic
Laboratory for Endocrinology and Metabolism,
Charles University, Prague

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Inhibition of Skeletal Formation in the Chick Embryo following Administration of Tetracycline

It has been shown that tetracyclines form complexes with metallic ions[1,2], that they become incorporated into bones of young mice[3], and also that they are retained in bones of several other species for a considerable period following administration[4-5]. We have recently demonstrated[6] that tetracycline inhibits skeletal formation in the sand dollar (*Echinarachnius parma*) embryo. The above observations prompted us to extend our previous studies and test the effect of the administration of

tetracycline on developing chick embryos with special reference to the formation of the skeleton.

Our experiments consisted in brief of injecting tetracycline (achromysin) into the yolk-sac of embryos eight days old in amounts ranging from 0·1 to 2·5 mgm. The embryos were examined two, four, six and eight days afterwards. The presence of tetracycline was identified by its characteristic fluorescence in the presence of ultra-violet light.

Administration of 0·5 mgm. per embryo is followed by rapid distribution of the drug throughout the embryo. 24 hr. later the drug appears exclusively in the calcified portions of the skeleton (Fig. 1). When

Fig. 1. Photograph of embryo injected on the eighth day with ½ mgm. of tetracycline, killed and photographed in ultra-violet light 24 hr. later. Whites area indicate fluorophor in skeleton. (× 2)

2·5 mgm. of the compound was injected, a pronounced retardation in overall growth occurred which was evident in embryos 10, 12, 14 and 16 days old.

Microscopic examination of the femurs of the treated embryos show several abnormal characteristics. They exhibit a marked bending, the number of trabeculæ are reduced, and the degree of mineralization is less than half observed in normal bones. In addition, the periosteum is thickened, the development of the hæmopoietic elements is arrested, and chondrogenesis is retarded. The net result of these several disorders in the growing structure lead to the production of a stunted, malformed bone.

Our studies have shown uptake and retention of tetracycline by the growing bones of embryos as previously described[3–5] for young adult animals. We have also demonstrated that administration of tetracycline to embryos results in marked inhibition and malformation of the growing bones. Inasmuch as tetracyclines are frequently employed in clinical practice, the results we have reported may be important.

Full details of the experiments performed will be published elsewhere. This study was supported (in part) by Grant No. *D*–643 U.S. Public Health Service, N.I.D.R. The tetracycline used was generously supplied by Lederle Division, American Cyanamid Co., Pearl River, N.Y.

GERRIT BEVELANDER
HIROSHI NAKAHARA
GLORIA K. ROLLE

Department of Histology,
College of Dentistry,
New York University,
New York City, N.Y.
July 23.

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Culture of Algae and other Micro-organisms in Deuterium oxide

THERE can be no doubt that algae forced to grow autotrophically in high concentrations of deuterium oxide are confronted with a difficult situation. Nevertheless, recent statements that moderate concentrations of deuterium oxide stop cell division in *Chlorella*[1], that the growth of *Chlorella* is "extremely slow, sporadic and unpredictable"[2] at high concentrations of deuterium oxide, and that autotrophic growth of *Chlorella* is "inhibited completely in 90 per cent heavy water"[3] must have only very limited validity. It is in fact entirely feasible to culture several species of algae autotrophically in 99·6 per cent deuterium oxide and at a growth-rate such that they become a practical source of fully deuterated compounds[4].

Algae require a prolonged period for adaptation or acclimatization to deuterium oxide. We have observed that an adaptation time of at least 200 hours is usually necessary before appreciable growth occurs. Such protracted adaptation periods appear to be far longer than those previously employed, and this may account for the failure of earlier workers to observe growth in deuterium oxide. Algae from old water cultures appear to adapt faster than young cultures, but the factors involved in the adaptation process are still very obscure. Once adaptation does occur, subsequent transfers to deuterium oxide produce immediate growth. Although morphological abnormalities are common during the adaptation period, fully adapted organisms cultivated for long periods in deuterium oxide appear quite normal under the microscope.

Three species of green algae have been successfully adapted to growth in 99·6 per cent deuterium oxide. Cultures of *Chlorella vulgaris* and *Chlorella pyrenoidosa* were obtained from the late Dr. Robert Emerson, and *Scenedesmus obliquus* from Prof. H. Gaffron; other cultures of these organisms were obtained from the Algae Collection of Indiana University. For *Scenedesmus obliquus* the following nutrient solution is presently used (gm./l.): $MgSO_4$, 0·48; $(NH_4)NO_3$, 0·80; NaH_2PO_4, 0·20; $KHCO_3$, 0·20; $Ca(NO_3)_2 \cdot 4H_2O$, 0·40; NaCl, 0·020; $FeSO_4 \cdot 7H_2O$, 0·030. For *Chlorella vulgaris* and *Chlorella pyrenoidosa* a somewhat different nutrient has been employed (gm./l.): KNO_3, 1·25; Na_2HPO_4, 1·00; KH_2PO_4,

0·25; $MgSO_4$, 0·125; $FeSO_4 \cdot 7H_2O$, 0·0054; NaCl, 2·00. Both media contain trace elements (in parts per million): B, 0·5; Mn, 0·25; Zn, 0·05; Cu, 0·02; Mo, 0·05. The addition of sodium chloride is found to exercise a markedly beneficial effect on the growth rate of *Chlorella* in deuterium oxide. Carbon dioxide is fed as a mixture of 5 per cent carbon dioxide–95 per cent nitrogen. The temperature is maintained at 26–28° C. The algae are continuously agitated in 200-ml. flasks on a rotatory shaker, or are grown in large transparent plastic boxes. Light of an intensity of about 600 ft.-candles is supplied by a panel of fluorescent lamps.

Scenedesmus obliquus has shown the fastest growth under our culture conditions. In ordinary water, we have observed a growth rate of 0·55 gm. (dry weight) per litre per day. The adapted *Scenedesmus* in deuterium oxide medium, under the same conditions, has a growth rate of 0·30 gm. (dry weight) per litre per day. More recently, we have grown *Scenedesmus* on an 8-litre scale in a 'Lucite' box; under these conditions we have observed a growth rate of 0·22 gm. (dry weight) per litre per day. The algae were allowed to grow to a concentration of 8 gm. (dry weight) per litre, at which time a portion was harvested. A total of several hundred gm. (dry weight) of algae has been obtained in this way.

Blue-green algae can also grow in 99·6 per cent deuterium oxide. *Gleocapsa sp.* and *Oscillatoria sp.* have been adapted to growth in deuterium oxide on the nutrient solution used for *Scenedesmus* and under the other conditions given above. We consider it probable on the basis of these observations that other classes of algae will also be adaptable to growth in deuterium oxide.

We have also studied the effects of deuterium on the growth of the bacterium *Escherichia coli*, the yeast *Torulopsis utilis*, and the protozoan *Paramecium caudatum*. *E. coli* is easily grown in 99·6 per cent deuterium oxide using either fully deuterated acetate or fully deuterated glucose (isolated from fully deuterated algae[4]) as the carbon source. *T. utilis* (American Type Culture, Collection No. 9950) has been grown on fully deuterated glucose; the nutrient solution employed had the composition (gm./l.): $(NH_4)_2HPO_4$, 1·0; KH_2PO_4, 0·5; $CaCl_2$, 0·2; $MgSO_4$, 0·2; NaCl, 0·2; deuterated glucose, 10·0; algae extract, 1·0; and micronutrients as above. Although *T. utilis* ordinarily requires no bios factors for growth, in order to achieve growth in 99·6 per cent deuterium oxide we have found it necessary to add an algae extract prepared from deuterated algae. *P. caudatum* has been cultured in lettuce infusion in 60 per cent deuterium oxide; daily additions of small amounts of fresh lettuce infusions increase the tolerance level to at least 70 per cent deuterium oxide. During adaptation by serial subculture, monster forms of *P. caudatum* were observed, but the organisms now maintained at 60 per cent deuterium oxide are essentially normal in appearance, although they are somewhat smaller than usual.

We conclude that a variety of essentially fully deuterated organisms can be grown. We have already isolated fully deuterated glucose[4], and fully deuterated chlorophylls and carotenoids (following communication) from deuterated algae and no doubt these and other organisms will serve as a source of many other fully deuterated compounds.

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Henry L. Crespi
Sylvia M. Archer
Joseph J. Katz

Argonne National Laboratory,
Lemont, Illinois.

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Choroplast Pigments of Deuterated Green Algae

It has recently been found that green algae can be successfully grown in 99·6 per cent deuterium oxide[1]. Algae such as *Chlorella vulgaris* and *Scenedesmus obliquus* adapted to deuterium oxide thus provide a source of highly deuterated organic compounds. Since the organisms grow in deuterium oxide with carbon dioxide as the sole carbon source, the cells must be equipped for photosynthetic activity even though their organic matter is constructed with deuterium in place of hydrogen.

To ascertain whether possible modifications in the indispensable, photosynthetically-active pigments of the deuterated organisms have occurred on adaptation we have now isolated the chloroplast pigments of *Chlorella* and *Scenedesmus* and have measured their visible and infra-red absorption spectra. To this end, the pigments were extracted from freshly harvested algae with methanol plus petroleum ether and were separated by column chromatography on powdered sugar. The carotenoids were separated further by chromatography on magnesia–silica columns. In all respects, the chromatographic procedures were those which have been applied to plant pigment studies generally[2]. The only significant difference was that precautions were taken to minimize contamination of the separated pigments by impurities containing hydrogen from the sugar columns. Each pigment was also crystallized from suitable solvents and dried in vacuum.

As shown by the colour and sequence of the zones in the chromatographic columns, and as indicated by the spectra of the pigments in the visible region, the deuterated chloroplasts contained pigments corresponding to chlorophyll *a*, chlorophyll *b*, α-carotene, β-carotene, lutein (xanthophyll), zeaxanthin, violaxanthin, and neoxanthin, and a xanthophyll characteristic of green algae which is sorbed between violaxanthin and neoxanthin on columns of sugar[2]. No new bands were found in the chromatograms from the deuterated algae, and none of the usual bands was absent. Chloroplasts of the deuterated green algae thus have the normal complement of pigments.

The absorption spectra of chlorophylls *a* and *b* from deuterated algae and from ordinary spinach, for comparison, were measured in the visible region. Wave-lengths and relative intensities of the absorption maxima are summarized in Table 1. No significant differences in either position or relative intensities of the absorption maxima are apparent in the chlorophylls from spinach and from the deuterated algae. Similar relationships were found among the spectra of the carotenoids. Possible changes in the magnitude of the extinction coefficients remain to be ascertained.

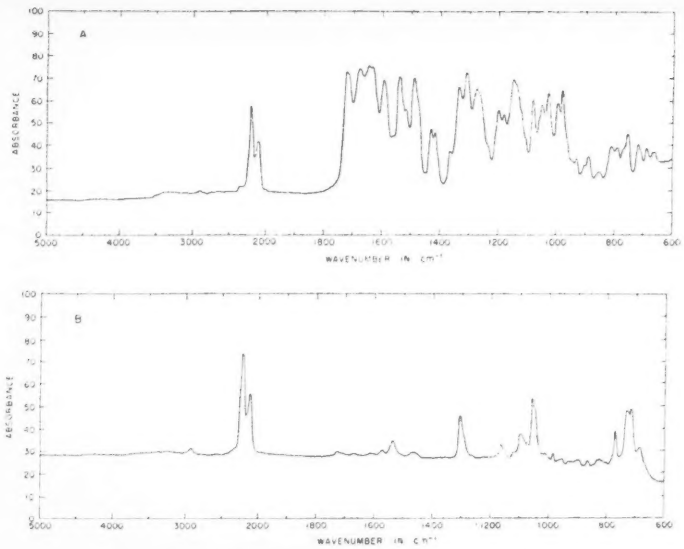

Fig. 1. Infra-red absorption spectra of thin films of chlorophyll *a* (*A*) and β-carotene (*B*)

The infra-red absorption spectra of the chloroplast pigments were measured with thin films formed by melting a suitable amount of the compound on a potassium bromide plate. Infra-red spectra of ordinary pigments measured in this way agreed well with the respective spectra, of chlorophylls[3] and β-carotene[4], described in the literature. Infra-red spectra of deuterated chlorophyll *a* and β-carotene are reproduced as *A* and *B* respectively in Fig. 1. In these spectra, and in those of the other deuterated pigments, the prominent C–H absorption at 2,900 cm.$^{-1}$, due to C–H stretching vibrations, is essentially absent and is replaced by the C–D absorption at 2,100–2,200 cm.$^{-1}$. As C–H impurities may be introduced from the sugar columns and the solvents, the small amount of C–H absorption apparent in *B* is probably not significant. In all of the deuterated carotenoid spectra so far examined a characteristic two-banded absorption occurs in the 700–800 cm.$^{-1}$ region; no corresponding absorptions were noted in the hydrogen prototypes. The band at 962 cm.$^{-1}$ characteristic of normal carotenoids is absent in the deuterated forms. We conclude from the infra-red spectra that in the pigments obtained from deuterated algae essentially all the hydrogen positions are occupied by deuterium, and the deuterated pigments are effective in photosynthesis.

Table 1. Comparison of Absorption Spectra of Chlorophylls *a* and *b* from Spinach and from Deuterated Algae (Solvent, Methanol)

	Absorption maxima (mμ)				Relative intensities of absorption maxima Blue max./Red max.	
	a		*b*			
	Red	Blue	Red	Blue	*a*	*b*
Spinach	660	433	647	472	1·00	2·88
Deuterated algae	661	432	647	470	1·00	2·87

We are indebted to Dr. Winston M. Manning for helpful discussions and support of these investigations, and to Mrs. Mary Thomas for measurement of the spectra. A fuller account will be published elsewhere. This communication is based on work performed under the auspices of the U.S. Atomic Energy Commission.

Harold H. Strain
Henry L. Crespi
Joseph J. Katz

Argonne National Laboratory,
Lemont, Illinois.

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Complex Reaction in *Hyoscyamus niger* upon Night Interruption with Red Light

In general, long-day plants form rosettes in short days (in white light), and flower stalks in long days. The dependence on the wave-length of radiation of this photoperiodic reaction can be determined in three different ways: (*a*) by growing plants exclusively in light of narrow wave-length bands, at high intensity, (*b*) by extending short white days with a coloured light treatment, and (*c*) by interrupting the long night, in a short-day treatment, with coloured light. Most results on the spectral dependence of the photoperiodic reaction have been obtained with the night interruption technique. These results appear rather clear-cut, which is the main reason why the two other possible modes of approach have only been used incidentally. Moreover, the results obtained from the other methods were not taken too seriously if they disagreed with the results of night-interruption experiments.

In this communication, some preliminary results are presented which show that results obtained with night interruption may even deviate from the well-known scheme, thus warning against a too simple interpretation.

Literature on night interruption with coloured light in *Hyoscyamus niger* is very restricted. Parker *et al.*[3]

reported on the spectral dependence without bringing into account the red-antagonizing activity of near infra-red (that is, far red) radiation. This gap was filled by Piringer *et al.*[4] and by Downs[1]. Stolwijk and Zeevaart[5], from this laboratory, also reported red light to be most effective. Admixture of near infra-red to the red radiation diminished its activity. Stolwijk and Zeevaart required considerably higher light intensities than the previously mentioned authors[1,4] to obtain an effect. They suggested that the reason for this difference might be that the basic day-length they used was shorter than that applied by Piringer *et al.* and by Downs. Stolwijk and Zeevaart's results were confirmed in this laboratory[6]. One hour of red radiation (~ 1000 ergs/sec. cm.^{2}) was insufficient to cause stem formation within 70 days of treatment[6]. It may be relevant that not only was the day-length different from that applied by the American authors, but also the light quality of the basic radiation period. Sunlight was used by Downs[1], whereas Stolwijk and Zeevaart[5], and Wassink and Sytsema[6] used fluorescent light with a much weaker near infra-red admixture.

In the following experiment a basic radiation period of 8 hours white fluorescent light of high intensity (~ 20,000 ergs/ sec. cm.^{2}) was supplemented with 2 hours of near infra-red at low intensity (~ 1,000 ergs/ sec. cm.^{2}) and applied as short-day treatment, instead of white light only. The aim was to obtain a reaction more similar to the one with sunlight. The long night was interrupted around the middle with low intensity (~ 1,000 ergs/sec. cm.^{2}) red light for 0, 1, 15, 30, 60, or 120 minutes. The numbers of days to the beginning of stem elongation (mean out of 4 plants) are presented in Table 1.

Table 1. Stem elongation in *Hyoscyamus niger*, as influenced by short days (8 hours' high intensity fluorescent white (*W*) supplemented with 2 hours' low intensity near infra-red radiation (*i*)) in combination with red (low intensity) night interruptions of different durations. High intensity is about 20,000 ergs/sec. cm.^{2}; low intensity is 1,000 ergs/sec. cm.^{2} Temperature about 20° C. The experiment started on October 17, 1957, and was closed after 78 days. Figures presented are averages of 4 plants each.

Radiation treatment		Days to beginning of stem elongation
Basic	Night interruption (min., red light)	
8 *W* + 2 *i*	120	41
8 *W* + 2 *i*	60	55
8 *W* + 2 *i*	30	>78
8 *W* + 2 *i*	15	>78
8 *W* + 2 *i*	1	>78
8 *W* + 2 *i*	0	50

Night interruption with low-intensity red light for two or even one hour produces the long-day reaction. Shorter interruptions are ineffective.

However, this description of the results is too simple because the group without any red night interruption also reacted as if it had received a long-day treatment. (This result has been reported earlier[2]). We must admit that very short night interruptions with red light suppress the long-day reaction, produced by this special short-day treatment, namely, 8 hours white fluorescent light plus 2 hours near infra-red. Longer interruptions are about neutral (1 hour), or are somewhat favourable for stem elongation (2 hours). Thus, in this experiment, the long-day plant *Hyoscyamus niger*, treated with short days permitting stem formation, could be kept vegetative with short red interruptions in the middle of a long night. Obviously, near infra-red supplemented to the basic white light period within a short day had converted the long-day plant *Hyoscyamus niger* into a short-day one. This was manifest directly[2], and also with respect to its reaction upon short interruptions in the middle of the night. This does not hold for longer night interruptions which restore the original behaviour.

P. J. A. L. de Lint

Laboratory for Plant Physiological Research, Agricultural University, Wageningen, Netherlands.

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Isolation of 24-Methylene-cholesterol from Honey Bees (*Apis mellifica* L)

In connexion with an attempt to isolate pheromone[1] from the queens of the honey bee, *Apis mellifica* L., an examination was carried out on the neutal portion of the extract obtained by perfusion of the powdered whole-bodies of the queens with ethanol and *tert*-butanol. By chromatographing the neutral portion on alumina, or silica gel, a crystalline substance, m.p. 138–145° C. $[\alpha]_D^{25} = -31{\cdot}6 \pm 6°$ ($c = 0{\cdot}39$ in chloroform), was obtained, which resembled cholesterol in behaviour and chemical properties. The Liebermann-Burchard reaction gave the same coloration as that obtained with cholesterol and the mixed melting point was the same. However, there were two bands (6·08μ and 11·33μ) in the infra-red spectrum of the substance which are not found in the spectrum of cholesterol and its derivatives. The same substance was isolated by similar means from worker bees. The constitution 1 for the sterol was elucidated from the following: An Oppenauer oxidation using cyclohexanone and aluminium isopropylate in toluene produced a conjugated unsaturated ketone; m.p. 77–84° C., $\lambda_{max} = 242$ mμ, $\log \varepsilon = 4{\cdot}0$ calculated for $C_{28}H_{44}O$, 396·6. Besides, the double bond of the $\alpha\beta$-unsaturated ketone function, a second double bond was present as shown by titration with bromine[2] (1·155 mgm. of substance used, in 4 hr., 0·934 mgm. bromine which corresponds to 2·01 moles $C_{28}H_{44}O$ by calculation. From the absorption bands at 6·08μ and 11·33μ (pressed in potassium bromide) it was inferred that one of the double bonds was present[3] as a methylene group (C = CH_2). Similarly 26 per cent of the theoretical yield of formaldehyde was formed on reaction with 10 moles of ozone. Based on these properties we have compared the free sterol and the O-acetyl-compound with 24-methylene-cholesterol and its O-acetyl-derivative[5] (Table 1).

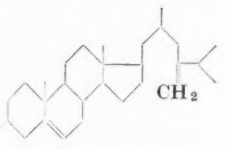
Table 1. Comparison of 24-Methylene-Cholesterol from Different Sources

	Free sterol I		O-acetyl-compound II	
	m.p.	$[\alpha]_D$ $CHCl_3$	m.p.	$[\alpha]_D$ $CHCl_3$
Authentic sample from oysters[6]	143°	−34·8°	135°	−44·1°
From queen bees	138–145°	−31·6 ± 6°	131–136°	−42·4 ± 3°
From worker bees	138–140°	−31·6 ± 2°	130–134°	−40·35 ± 1°

A sample of O-acetyl-24-methylene-cholesterol was shown, by direct comparison, to be identical with the O-acetyl-derivative of the sterol isolated from the bees. This comparison included mixed melting-points, infra-

red spectra in methylene dichloride and in potassium bromide and examination in the mass-spectrometer.

The X-ray powder diagram did not exclude the positive identification. For real proof however, it would have been necessary to recrystallize both samples under the same conditions[9] but due to the scarcity of the substance this was not possible. The percentage of I amounted to about 0·016 per cent in both the workers and the queens.



I R = H, m.p. 143° (− 34·8° *Chf.*)
II R = *Ac*, m.p. 135° (− 44·1° *Chf.*)

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M. Barbier
T. Reichstein
O. Schindler

Institute for Organic Chemistry,
University of Basle.

E. Lederer

Institut de Biologie Physico-Chimique,
Paris.
June 8.

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RADIOBIOLOGY

Distribution of Radioactive Barium in Eye Tissues

The presence of high concentrations of barium in the pigmented tissues of the eye of many species is now well established[1,2]. The observations on barium-140 reported here demonstrate that this radioactive isotope of the element is markedly concentrated in the uveal tract of herbivores.

Pure-bred Dutch rabbits about 10 weeks old were used. Pairs of animals were injected intravenously with approximately 500 μc. of an equilibrium mixture of pile-produced, carrier-free barium-140 and lanthanum-140 and were killed by an intravenous injection of 'Nembutal' at intervals of from 30 min. to 3 days from the time of injection. The eyes were removed and dissected immediately after death. The left femur, left vastus muscle and a sample of heart blood were also taken for analysis. The tissues were digested with concentrated nitric acid, and after standing for 6 days to allow for equilibration between the barium-140 and its lanthanum-140 daughter, suitable aliquots of the resulting solutions were assayed in a well-type scintillation counter. The results, corrected for radioactive decay, are given in Table 1.

Table 1. Distribution of Stable Barium and of Intravenously Administered Barium-140 in the Eyes, Etc., of Rabbits

	Stable Barium (μgm./100 gm. wet-weight)	Barium-140 (per cent dose/100 gm. wet-weight of tissue) after:					
		30 min.	1 hr.	3 hr.	7 hr.	24 hr.	72 hr.
Cornea ..	22	0·85; 1·17	0·99; 1·08	0·68; 0·80	0·30; 0·51	0·078; 0·036	0·012; 0·019
Iris and ciliary body ..	191	2·96; 3·29	2·88; 4·08	3·98; 4·84	3·09; 4·23	4·77; 3·11	2·06; 4·67
Lens ..	5·5	0·037; 0·033	0·018; 0·025	0·016; 0·028	0·010; 0·012	0·0033; 0·0042	0·00067; 0·0022
Vitreous body	1·2	0·16; 0·11	0·096; 0·14	0·083; 0·13	0·028; 0·043	0·0054; 0·0076	0·0030; 0·0038
Retina ..	36	0·61; 0·98	0·61; 0·77	0·70; 0·88	0·49; 1·21	0·46; 0·17	0·085; 0·034
Choroid ..	348	10·8; 9·5	9·8; 15·2	8·7; 11·9	11·7; 18·7	19·8; 9·2	10·3; 10·6
Sclera ..	22	1·91; 3·53	3·93; 4·04	2·27; 2·04	1·95; 1·14	0·61; 0·74	0·050; 0·44
Plasma ..	—	2·12; 1·75	1·17; 0·89	0·32; 0·33	0·15; 0·33	0·013; 0·021	0·0068; 0·0049
Muscle ..	—	0·62; 0·26	0·22; 0·37	0·10; 0·39	0·041; 0·033	0·013; 0·024	0·0020; 0·0028
Femur ..	—	4·75; 5·03	7·78; 10·2	8·36; 9·58	7·42; 12·3	8·69; 8·51	8·49; 7·63

This table also shows the concentrations of stable barium in the tissues of the pooled eyes of sixteen similar rabbits determined by the method described by Sowden and Stitch[3].

The eyes of two mature cows given approximately 3 mc. barium-140/lanthanum-140 for another purpose have also been examined. These animals were killed 8 and 25 days after administration of the isotope. The eyes, together with the left femur and a piece of the left vastus muscle, were removed immediately after slaughter. The tissues were treated as described above. The distribution of the isotope is shown in Table 2.

Table 2. Distribution of Stable Barium (from Sowden and Pirie, ref. 2), and of Intravenously Administered Barium-140 in the Eyes, Etc., of Cows

Tissue	Stable barium (μgm./100 gm./ wet weight)	Barium-140 (per cent dose/ 100 gm. wet weight of tissue) after:	
		8 days	25 days
Cornea	70; 3	0·0032	0·0030
Iris and Ciliary body	18,700; 20,600	0·35	0·47
Lens	5; 6	0·0002	0·0009
Vitreous body	—	0·0001	0·0002
Retina	56; 129	0·0027	0·0027
Choroid and tapetum	20,000; 66,000	1·03	0·82
Sclera	17,700	0·064	0·027
Muscle	—	0·00003	0·0002
Femur:			
Proximal end	—	0·093	0·081
Shaft	—	0·047	0·046
Distal end	—	0·097	0·073

together with, for the purpose of comparison, the stable barium content of cow eye tissue as found by Sowden and Pirie[2].

The uptake and retention of barium-140 by the different parts of the eye differed several-fold in both species. All parts of the rabbit's eye, except the lens and vitreous body, accumulated barium-140 to a greater extent than the vastus muscle, taken as a representative soft tissue. The highest concentration of the isotope, in both rabbits and cows, was in the pigmented parts of the eye. The concentration in the choroid, on a unit wet-weight basis, was greater than that in the femur, in the rabbit, by a factor of about 1·5, and in the cow, by an order of magnitude. Barium-140 remained at least as firmly fixed in the uveal tract as in the femur but disappeared from other parts of the eye, except the sclera, at approximately the same rate as from striated muscle. The sclera occupied a position intermediate between that of the pigmented tissues and the remainder of the eye.

The relative proportions of barium-140 in the different tissues after 3 days in the rabbit and after 8 and 25 days in the cow were very similar to the relative proportions of stable barium.

The high degree of accumulation of barium-140 in the choroid and iris of the cow may be of significance should it be found necessary to decide on a maximum permissible level for the isotope in this species.

R. J. Garner

Radiobiological Laboratory,
Agricultural Research Council Field Station,
Compton, Berkshire.
May 19.

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Effects of Irradiation of Nerve on Muscular Response

The effects of gamma- and X-radiation on the excitability and conductivity of the sciatic nerve of the frog have been studied for doses up to 80,000r. and an attempt made to correlate these results with the muscular response. Either the whole nerve or a short segment was irradiated. Excitability and conduction velocity of the nerve and the response of the attached gastrocnemius muscle, were recorded both during and after irradiation. Observations were also made of the mechanical activity of the nerves. No stimulation of the nerve by irradiation was observed, but complex and paradoxical effects on the excitability of non-irradiated segments were found.

Isolated sciatic nerve preparations from the common frog (*Rana pipiens*) were mounted on platinum electrodes in a humid 'Plexiglas' chamber similar to that employed by Chailakhian and Iur'ev[1]. The temperature was maintained at 18° — 20°C. Stimulation was produced by a 'Tektronix' waveform generator, using 30 — 40 second bursts of 0.1 msec. pulses at 50/sec. Stimulus strengths slightly above maximal were used. Platinum wire electrodes were used for stimulating and recording the action potentials. The nerves were stimulated during irradiation and for periods of several hours after irradiation.

Sciatic nerve-gastrocnemius muscle preparations were made after the method of Kirzon[2]. Two nerve muscle preparation were placed in the two compartments of a humid 'Plexiglas' chamber. The nerve of each preparation was mounted on four pairs of platinum wire electrodes for stimulation, one proximal and three distal to an irradiated segment. Stimulation was produced as above, but using 30—40 second bursts of 1 msec. pulses. Two different levels of stimulation were applied, threshold and maximal. Muscular responses were registered on a conventional kymograph using an isotonic lever system.

For gamma-irradiation, a cobalt-60 'Teletherapy' unit was used, and for X-irradiation, a conventional X-ray machine with an aluminium filter. For irradiation of isolated sciatic nerve, 250 kVp. at 20 m.amp. were used, at a dose-rate of 7,000r./min. In the nerve-muscle experiments, irradiation was limited to a 7-mm. segment of the nerve by shielding the rest of the nerve, the control nerve and the muscle with 3 cm. lead shielding. For X-irradiation, 50 kVp. at 20 m.amp. were used, at a dose-rate of 350-600r./min.

Nerve surface displacements were detected by a micro-interference method, similar to that of Kayushin and Lyudkovskaya [3,4]. Deflection of an interference fringe in the light reflected from the nerve surface provided a measure of surface movements.

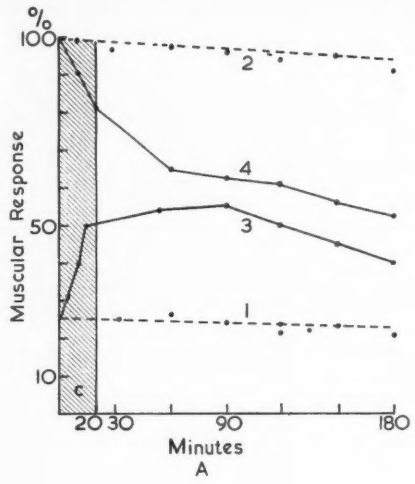
In the isolated sciatic nerves, in non-irradiated controls, conduction velocities averaged 28.5 ± 2 m.sec. Conduction velocities were unaffected by radiation doses up to 10,000r., in agreement with the results of Gerstner [5,6]. For doses up to 10,000r. and 50,000r., the conduction velocity increased 5 per cent and for doses between 50,000 and 80,000r. it decreased 12 per cent and the amplitude of the action potential decreased slightly. In sciatic nerve-gastrocnemius muscle preparations, the irradiation with gamma- or X-rays of the whole nerve trunk, or of a small segment with doses up to 10,000r. produced no muscular response, regardless of the dose-rate (20—7,000r./min.)

Complicated and paradoxical effects on the excitability of the non-irradiated segment of the nerve were found. A decrease in threshold was produced by doses ranging from 1,500r. to 20,000r. and the magnitude of this effect depended on the dose rate, but it could be more readily detected when employing dose rates ranging from 350 to 600r./min. Paradoxically, the same dose and dose-rate ranges that produced a decrease in threshold, produced a decrease in the muscular response to a maximal stimulus. The results for stimulation of the nerve distal to the irradiated segment are summarized in Fig. 1.

The observation of Kayushin and Lyudkovskaya[3,4] indicated the occurrence of a compressional wave passing along the nerve during stimulation. Hill[8,9] showed that changes during the electrical activity of a nerve fibre were accompanied by changes in optical density. It is possible that there is a correlation between these phenomena. We have been able to confirm the Russian reports using micro-interference measurements and also to show that in nerve irradiated in the same dose range as above these displacements were intensified in the distal segment of the nerve.

Increased excitability in the distal segments of irradiated nerves has been reported by Kirzon[7]. On the basis of his results, Kirzon has suggested a theory of "non-impulse effects" in nerve, which may explain the results reported here.

If we assume that the 'displacement' of the surface during electrical stimulation, accompanied by density changes, represent actual transport of substances along the nerve, then the increased displacements



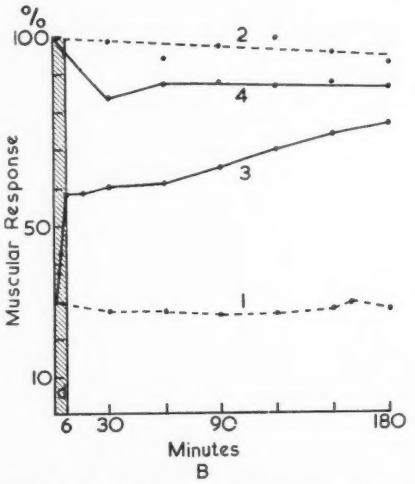


Fig. 1. Results of stimulation of the nerve distal to the irradiated segment. *A*, Muscle responses during and following irradiation with 500r./m. for 20 min.; *B*, muscular responses during the following irradiation with 500r./min. for 6 min.
The lined segments *c* and *d* represent the period of irradiation. Abscissae shows the time (min.). Ordinates show muscular responses expressed in percentages.
1, Muscular response for threshold stimulation (without irradiation); 2, muscular response for maximum stimulation (without irradiation); 3, muscular response for threshold stimulation (with irradiation); 4, muscular response for maximum stimulation (with irradiation).

produced by stimulation which follows irradiation may represent an increase in this transport.

If we further assume that these transported substances include the mediator for neuromuscular transmission, then the paradoxical results obtained here could be explained as being due to excessive accumulation of this mediator. Such accumulation would be expected to lead to increased response at low levels of stimulation, and decreased response at maximal or saturation levels, as actually observed.

To test this concept, experiments are being designed which will use isotopically labelled acetylcholine and K-42 to follow their displacements along the nerve during stimulation, both before and after irradiation. The micro-interferometer is being improved so that the surface movements can be analysed with accuracy.

A. Portela
D. Brandes
Anatomy Department G. H. Bourne
Marion Hines
Physiology Department P. Stewart
Radiology Department B. L. Redd, jun.
Emory University,
Atlanta, 22,
Georgia

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Latent Period of X-Ray Induced Ageing: a Study Based on Mortality Rate and Tumour Incidence

The increase in age-specific chronic mortality rate that occurs after a single whole-body exposure to ionizing radiation has been commonly used as a parameter of ageing[1]. Whether or not the increase occurs immediately or only after a latent period is not known, owing to the fact that experiments are customarily initiated with young animals, for example, 50- to 125-day-old mice. The mortality rate is then so low that not even a large relative increase can be significantly established in groups of 50 animals.

We therefore designed an experiment to study this point. Groups of *BALB/c* mice (70–80 males, 101–115 females), made up from a single pool, served as controls or were irradiated at age 435 days (405–460 days) or at age 535 days (505–560 days). The X-ray exposure dose in soft tissue was 500 r. (250 kV., hvl. 1·5 mm. copper, 45 r./min.). This dose was selected to avoid 'acute' killing. The *LD* 50/30 was estimated to be about 560 r. The animals were exposed and maintained as described previously[2].

At age 435 days, 500 r. proved to be the *LD* 3/30 for males and the *LD* 1/30 for both sexes combined. At age 535 days, 500 r. was the *LD* 40/30 for males and the *LD* 10/30 for females. Therefore, although the conclusions drawn from the chronic mortality rate data of the 535-day groups may have been in qualitative agreement with those for the 435-day groups, for simplicity and brevity they are not considered here.

For Table 1 the mortality rate q_x was calculated thus: (number dying in 8-week interval beginning at age specified) divided by (number alive at start of interval). To test for significant differences between the control and irradiated groups, χ^2 (with Yates' correction) was calculated for the pooled data of 2 or 3 successive 8-week intervals.

In the irradiated male, a latent period of 24 weeks (intervals 1–3) elapsed before q_x rose significantly above the control level. During the remaining 56 weeks (intervals 4–10), q_x continued at about 2–4 times the control level. In the female, the latent period lasted 16 weeks. For the next 48 weeks (intervals 3–8) q_x usually was 2–3 times the control level, after which it fell.

Table 1. Mortality-Rate q_x after Exposure at Age 435 Days*

Interval (8-week)	Age (days)	Male			Female		
		0 r.	500 r.	χ^2	0 r.	500 r.	χ^2
1	435	0·013	0·043	< 1	0·026	0·010	< 1·5
2	491	0·013	0·030		0·036	0·020	
3	547	0·026	0·015		0·056	0·112	9·8†
4	603	0·053	0·203	12·3†	0·029	0·161	
5	659	0·086	0·261		0·102	0·223	6·6†
6	715	0·129	0·233	4·2‡	0·209	0·353	
7	771	0·171	0·365		0·200	0·335	6·5†
8	827	0·233	0·400	4·5‡	0·231	0·524	
9	883	0·364	0·778		0·425	0·300	< 2
10	939	0·571	1·0§	——	0·783	0·571	——
11	995	0·778			0·60§	0·67§	
12	1051	0·50§			1·00§	1·00§	
13	1107	1·00§					

* Data were corrected for 6 animals in each group killed between ages 683 and 786 days.
† $P = 0{\cdot}02$–$0{\cdot}001$.
‡ $P = 0{\cdot}05$.
§ Only 1–5 animals alive at beginning of interval.

The existence of latent periods is consistent with the simple general theory of the late effects of irradiation presented elsewhere[3]. Presumably the duration of the latent period varies with the nature of the pathological processes that lead from the initial radiation injury to death, and these in turn depend on age, sex, strain, species, and dosage.

Since late effects after the exposure of older animals have not been reported previously, it was of interest to record our data for life shortening and tumour incidence.

Averaging the results for both sexes, the control median life span was 840 days (males, 855; females 825 days). The decrements in life span were 15 weeks (exposure at age 435 days) and 9 weeks (exposure at age 535 days, corrected for acute deaths), equivalent to 26 and 20 per cent, respectively, of the life span remaining at the time of exposure. These results suggest that older animals may suffer less life shortening than younger ones of the same strain[2].

To study gross tumour incidence, autopsies were done when feasible on animals of both the 435- and 535-day groups that died after age 603 days, thus avoiding 'acute' deaths without materially selecting against the 'chronic' ones. Histological examinations were made when necessary to confirm gross findings. The group autopsy rate averaged 36 (29–41) per cent.

Gross tumour incidence was reduced in the irradiated groups (males 0·77–0·59, females 1·13–0·69 per animal). Therefore the radiation-induced acceleration in mortality rate discussed above was not due to an increase or an acceleration in neoplasia. The decrease throughout the observation period in total tumour incidence resulted from a decrease in abdominal lymphomas (chiefly reticulum cell sarcomas and stem cell lymphosarcomas). The pooled male and female lymphoma incidence was: age 604–827 days, 8/16 control, 8/57 irradiated, $\chi^2 = 7{\cdot}5$, $P < 0{\cdot}01$; age 828–1135 days, 13/48 control, 1/34 irradiated, $\chi^2 = 6{\cdot}6$, $P = 0{\cdot}01$.

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H. I. Kohn

Radiological Laboratory,

P. H. Guttman

Cancer Research Institute,
University of California Medical Center,
San Francisco 22, California.

June 27.

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Excretion of Labelled Magnesium by the Sheep

Knowledge of the routes by which magnesium is excreted by the ruminant and the mechanism of control of such excretion is of value in connection with the ætiology of hypomagnesæmia. The work to be described is of a preliminary nature owing to the high cost of the radioisotope used. It includes a determination of the endogenous fæcal magnesium excretion and its comparison with renal magnesium excretion.

The subject used was a Cheviot wether aged about 20 months and of shorn weight 45 kgm. This sheep was maintained in a metabolism cage on a diet of good-quality hay and water (both obtained from the Edinburgh district) throughout the metabolic trial and for one week beforehand.

At zero time, approximately 120 μc. of carrier-free magnesium-28, in about 12 ml. 5·5 per cent aqueous glucose solution, was injected into the sheep subcutaneously. Fæces and urine collections were made at suitable intervals and analysed for both total and radioactive magnesium. For the measurement of their magnesium-28 content use was made of a modified ring counter.[1]

Fæces were analysed for magnesium, after initial preparation[2], by the use of titan yellow[3]. Urinary magnesium concentrations were also estimated by this method. The magnesium content of the hay diet was obtained by conversion to magnesium ammonium phosphate and estimation of this with amino-naphthol sulphonic acid[4]. All hay and fæcal samples were dried to the same temperature (136° F.) before analysis. The magnesium content of the drinking water was negligible.

Blood samples were taken at intervals from the jugular veins, using heparin as the anticoagulant. After centrifuging, the magnesium-28 content of the plasma was measured in an *M*.6 type liquid counter. The total plasma magnesium concentration was estimated using ammonium vanadate[5]. The erythrocytes were washed twice with an equal volume of aqueous 5·5 per cent glucose, centrifuging for 15 min. at 3,000 r.p.m. after each process. Finally, 5 ml. erythrocytes was haemolysed with 8·5 ml. distilled water and the magnesium-28 content of the resultant solution measured in a liquid counter. Its total magnesium concentration was then obtained using ammonium vanadate[5]. Samples of blood, urine and fæces were taken, and analysed as described, for as long as it was possible to estimate accurately their contents of magnesium-28.

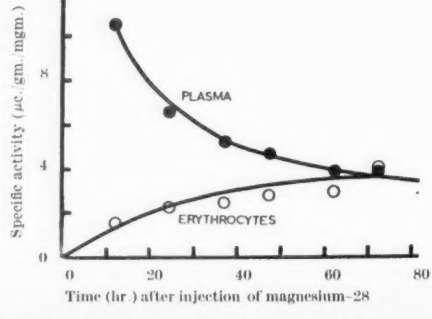

Fig. 1. Effect of time on the distribution of magnesium-28 between plasma and erythrocytes, following subcutaneous injection of magnesium-28 into sheep

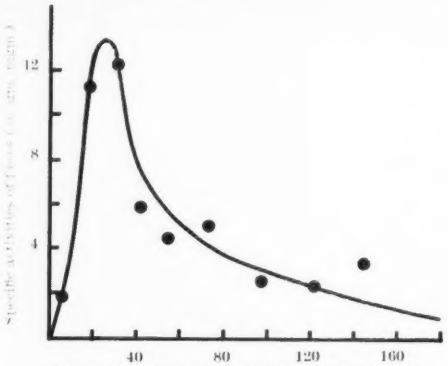

Fig. 2. Effect of time on the faecal excretion of magnesium-28, following subcutaneous injection of magnesium-28 into a sheep

Fig. 1 shows the concentrations of magnesium-28 in plasma and erythrocytes at different times after the injection of magnesium-28. In all cases, corrections were applied for radioactive decay and counter dead time.

About 70 hr. after the injection of the magnesium-28, equilibration of this magnesium appeared to have been established between the plasma and the erythrocytes. The logarithm of the plasma specific activity versus time curve was linear after 50 hr., so that plasma specific activities at times greater than 70 hr. after magnesium-28 injection could be obtained by extrapolation. This was necessary for the calculation of the endogenous faecal magnesium excretion.

The curve relating faecal excretion of magnesium-28 with time (Fig. 2) shows a peak about 25 hr. after the subcutaneous injection of magnesium-28. Using subcutaneously injected phosphorus-32 in sheep, Lofgreen and Kleiber[6] demonstrated that the extent of the endogenous faecal excretion of phosphorus could be estimated by the isotope dilution method[7]. They related plasma and faecal phosphorus-32 samples taken 24 hr. apart, under conditions of phosphorus-32 equilibrium throughout the sheep. Fig. 2 indicated that a similar time interval could be employed for magnesium-28 in the sheep. In this way, using the results shown in Figs. 1 and 2, the average daily endogenous faecal excretion of magnesium was calculated. It was 227 mgm.

During this period the average daily total faecal magnesium excretion was 1,258 mgm. and the average daily ingestion of magnesium, 1,399 mgm. The average daily absorption of magnesium was thus 368 mgm. and the true availability of the magnesium in the hay diet used, 26·3 per cent.

The total faecal excretion of magnesium-28 over the 6½-day period studied was 30·91 μc. and the total urinary excretion of magnesium-28 over the same period, 17·46 μc.; that is, a ratio of faecal to urinary excretion of magnesium, over this period, of 1·77. That the sheep was in magnesium balance over this period was reflected in the fact that the average total daily magnesium actually excreted, 355 mgm., approximated to the average daily magnesium absorption (368 mgm.).

The above results should be compared with those obtained by Field[8] who used the comparative balance technique[9] for the measurement of endogenous faecal magnesium excretion. His subject was an adult North Country Cheviot wether of unstated weight. The diet used was also hay and water from the Edinburgh district. He obtained a true availability of 25·8 per cent for the magnesium in this hay and a daily endogenous faecal magnesium excretion of 205 mgm.

The relatively close agreement between the results obtained by these two methods may be fortuitous because of the small number of sheep involved. Comar *et al.*[10] have obtained comparable values for endogenous faecal calcium excretion in the same cattle by the use of the two methods. The agreement achieved between our results and those of Field[8] may mean that 200–230 mgm. is the normal level of daily endogenous faecal magnesium excretion which accompanies a normal plasma magnesium level in the adult Cheviot wether. That is, any magnesium absorbed, in excess of that required for magnesium homeostasis, is excreted via the gut at the rate of 200–230 mgm. per day (when the plasma-level is normal) and the remainder excreted via the kidneys.

Field[8] also compared the relative amounts of magnesium excreted via the gut and kidneys. He obtained a value of 1·88 for the ratio of endogenous faecal to urinary excretion of magnesium. This compares well with our figure of 1·77, obtained over a longer period of study. This would seem to support his suggestion that the urinary route of excretion by the ruminant is more important for magnesium than it is for calcium.

We wish to record our appreciation for the financial assistance afforded us by the Secretary of State for Scotland and by the Animal Health Trust for one of us (A.D.C.).

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D. C. Macdonald
A. D. Care
Department of Veterinary Pharmacology,
Royal (Dick) School of Veterinary Studies,
Edinburgh.

B. Nolan
Royal Infirmary,
Edinburgh.

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BIOLOGY

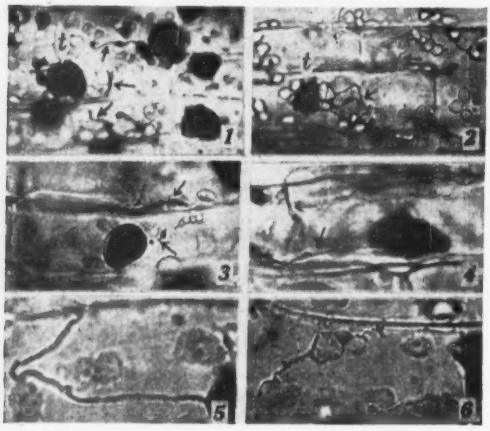
Changes in the Lacunal Parenchyma of *Mimosa pudica* in Diurnal and Nocturnal Conditions

I recently reported that in the petiole of *Mimosa pudica* L. there are thread-like apparatuses which are stained with a basic dye solution.[1] In another paper, the modes of the fixation of these thread-like apparatuses were described.[2] In the present note, records of observation on the cytophysiological changes in the lacunal parenchyma of the petiole in both the diurnal and nocturnal conditions are dealt with.

Mimosa pudica was cultivated in the same manner as has been described in the previous papers[1,2,3]. The material consisted chiefly of those plants which had already received a stimulus. The longitudinal sections were obtained by a cylinder microtome or simply by a hand razor, the petiole being cut 25–30μ in thickness. Then they were stained with 0·001 per cent aqueous solution of brilliant cresyl blue or 0·003 per cent neutral red, the adequate staining being almost complete after 20–30 min.

The tannin vacuole in the parenchymatous cell is more inflated during the day (10 a.m.–3 p.m.) than during the night (12 midnight–2 a.m.), and the thread-like apparatus is thicker during the day than at night. Furthermore, in the nocturnal condition the chloroplasts have a tendency to form a cluster around the thread-like apparatus (Figs 1 and 2).

Champy's fluid was used for the fixation of the parenchymatous cells. Adequate duration of fixation was about 20 hr. After completion of the fixation they were thoroughly washed in running water for



Figs. 1–6. Longitudinal section of parenchyma of *Mimosa* petiole. 1, diurnal condition; 2, nocturnal condition. 1 and 2 are stained with 0·001 per cent brilliant cresyl blue. (× *c.* 435). 3, diurnal condition; 4, nocturnal condition (× *c.* 530). 5, chloroplasts and threadlike apparatus in direct ray of sunlight. 6, chloroplasts and threadlike apparatus in nocturnal period. 3–6 are fixed with Champy-Toriyama's method. (× *c.* 830). *t*, tannin vacuole; arrows indicate threadlike apparatus.

10 hr. to remove any trace of the reagents. These materials were cut 25–40μ thick by means of a hand microtome. The sections were washed in running water, and then in distilled water, changed several times. The sections were mounted in pure glycerin, without any subsequent staining. This technique[2] was satisfactory in demonstrating the thread-like apparatus, and in fixing the chloroplasts. Generally speaking, osmium tetroxide usually stains the threads and tannin vacuoles black, while the chloroplasts remain colourless.

These results are illustrated in Figs. 3 and 4. In the diurnal condition, tannin vacuoles are fixed as a spherical form, and in the nocturnal condition they appear as crushed globes. The thread-like apparatus has a tendency to assume rosary-like features during the day. On the other hand, at night the threads appear uniformly in a thin slender form. When the materials are exposed to sunlight in August, small particulate granules appear in the chloroplast (Fig. 5). By Champy's fixation, these granules and threads are both stained black. On the other hand, at night the granules as a rule do not appear under this fixation (Fig. 6). But in certain conditions, these particulate black granules are observed in the chloroplast, also at night. These different features of chloroplasts in two cases were also observed in fresh material with vital staining.

From the available data of cytophysiological experiments, it is concluded that the expansion and contraction of the tannin vacuole in parenchyma is connected with the diurnal and nocturnal condition. Concerning this fact, it is advisable to refer to my work[4] on the changes in motor cells in the diurnal and nocturnal conditions. Full details of this investigation will be published elsewhere.

Hideo Toriyama

Biological Section,
Tokyo Women's Christian College,
Tokyo, Japan.
June 16.

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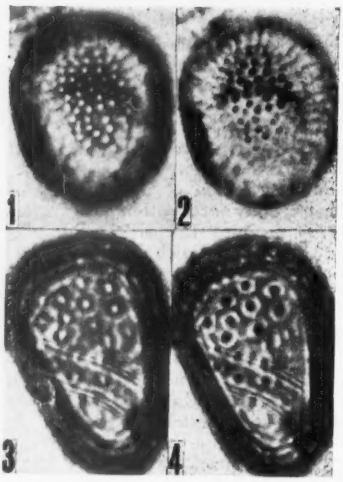
'LO-Analysis' as an Aid in the Study of Fungal Spore Morphology

Erdtman[1] defined *LO*- analysis as: "the different patterns of pollen or spore wall surfaces . . . recorded as they appear at successive adjustments of the microscope."

The usual practice is to select spores in slide mounts which are so oriented that they are seen in surface view. The surface is then examined in two focal planes. In the upper focus of the microscope the raised structures on the spore surface (here rounded warts or pointed spines) are seen as hyaline bodies (Figs. 1 and 3), while in the lower focus these same raised structures turn dark (Figs. 2 and 4). Figs. 1 and 2 show a single urediospore of *Scopella aulica*, and Figs. 3 and 4 are of *S. gentilis*. This was termed *LO*-analysis by Erdtman[1] (*L* denoting *lux* or lighted areas in the upper focus and *O obscuras* or dark areas in the lower focus). The reverse of this, that is, *OL*-analysis can be attempted where there are



Figs. 1 and 2. Urediospore of *S. aulica* at two successive adjustments of microscope (Fig. 1 at high focus; Fig. 2 at low focus; both × 5,800). Figs. 3 and 4. Urediospore of *S. gentilis* (Fig. 3 at high focus; Fig. 4 at low focus; both × 1,280)

depressed areas, holes or concavities present on the spore surface. *OL*-analysis is illustrated in Figs. 3 and 4. Around the spines (raised structures, hyaline in Fig. 3 and dark in Fig. 4) there are depressed areas (dark in Fig. 3 and hyaline in Fig. 4) which, following pollen grain terminology, have been designated as 'lumina'. These cavities are bounded by 'muri' which are part of a reticulum enveloping the spore surface.

Erdtman[1] credited H. Welcker as being the discoverer of this optical effect. In an ideal *LO*-analysis, all the raised structures in the upper focus should appear as bright dots against a black background. This is possible only if the spore surfaces are perfectly flattened. In Figs. 1 and 3, because of the convex bulge in the spores, only a few spines are seen in such an ideal condition.

Perhaps, through *LO*-analysis, some more unsuspected characters might come to light, as has happened in the case of urediospores of *Scopella gentilis*. Here the presence of lumina around the spines and of the reticulum around the urediospore surface was first inferred through *LO*-analysis. *LO* analysis might even be important where paucity of spore material, for example, in aerobiology or in palæobotany, might not permit the use of other methods.

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M. M. Payak*

Maharashtra Association for the Cultivation of Science, Law College Building, Poona, India.

* Present address: Plant Pathological Station, Flowerdale, Simla E.

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Lepidurus arcticus in the Irish Late-Glacial

The recent discovery of a fine suite of Late-glacial strata near Ballyhalbert on the north-eastern Irish coast in an accessible position has allowed a careful study to be made of the different layers for plant and animal macrofossils. Particularly interesting has been the recovery of numerous characteristic telsons of the freshwater notostracan *Lepidurus arcticus*, a species which was reported recently by Mitchell[1] from Late-glacial levels at Ballaugh in the Isle of Man, at Neasham, Co. Durham, and at Mapastown, Co. Louth. Records from these Late-glacial contexts are significant since the species is not known in the present fauna of the British Isles. Its modern distribution is circumpolar, between 65° and 80° N.

At Ballyhalbert the telsons and mandibles occurred in great numbers in thin streaks of organic material which interrupted a solifluxion deposit of Zone III age. The deposit was a grey, sandy clay, packed with innumerable broken, angular fragments of slate. Within this the organic seams were lying horizontally. They yielded numerous leaves of *Salix herbacea* and also identified were *Carex* spp., *Ranunculus sceleratus*, *Ranunculus* (Batrachian) spp., *Rumex tenuifolius*, *Viola palustris*, *Hippurus vulgaris*, *Menyanthes trifoliata*, *Lycopus europaeus*, *Selaginella selaginoides*, and *Chara* spp. The large number of aquatics suggests that the organic seams had their origin as small pools. These perhaps formed each summer on top of the spring season's fresh sheets of solifluxion material. The possibility may also be envisaged that the seams are really fragments of the underlying Alleröd or Zone II mud which could have been caught up and rolled into the solifluxion clay as it sludged into position. However, this seems an unlikely explanation since no remains of *Lepidurus* were discovered in the Zone II level. It was clearly restricted to the Zone III clay and did not appear above or below this horizon.

The absence of *Lepidurus arcticus* from the existing British and Irish faunas makes its widespread Late-glacial distribution all the more remarkable. Examples of such extinction and retraction of range during Post-glacial times are of course more familiar to us in plant kingdom, and Godwin[2] has documented and discussed the problem in full. It is believed that the plants in question experienced curtailment of their range due to absorption of suitable habitats by the spread of the Post-glacial forests. But the factors responsible for the extinction of *Lepidurus* are otherwise and are difficult to envisage. Perhaps the problem may be approached constructively once quantitative and systematic studies on the sub-fossil micro-faunas of Late- and Post-glacial lake muds have accumulated to the extent of allowing the different factors in lake evolution[3] to be disentangled. Such studies are certainly to be commended since they may lead to a more accurate knowledge also of the duration and character of the important Post-glacial Climatic Optimum or Hypsithermal Interval.

M. E. S. Morrison*

Botany Department, The Queen's University, Belfast. May 4.

* Present address: Institut Botanique, Université de Montréal, 4101 est, rue Sherbrooke, Montreal 36, Canada.

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ENTOMOLOGY

Haematopota insidiatrix Austen (Diptera, Tabanidae) in Southern Rhodesia

The fly-round technique has long been used in tsetse fly studies[1,2]. The procedure is to walk along a pre-determined route collecting those flies attracted to men, to bait-animals or to screens carried by men. Recent work in the Wankie National Park, Southern Rhodesia, has shown that this method is also effective for the study of *Haematopota insidiatrix* Austen. This insect is frequently a nuisance at Wankie, during the rainy season (November–February), because of its habit of following and entering motor-vehicles. It was because of this behaviour that the fly-round technique was tried as an aid to their study. A black cloth screen carried by two boys was found to be attractive to the flies. The use of a screen rather than a bait animal allows the technique to be standardized and also to be used in an essentially new way, namely, to study certain aspects of the sensory physiology of this insect.

Portchinsky[3] noted that *Haematopota pluvialis* L. is attracted by black surfaces but that it avoids white ones. Curson[4] states that *Haematopota* sp. alighted on the black part of an animal's coat rather than the white part. In tsetse fly studies Swynnerton[5] has stressed the usefulness of screens and Lloyd[6] working with *Glossina swynnertoni* refers to a preference for

Table 1. Simultaneous Comparison of the Number of *H. insidiatrix* Caught on a Black Screen and on a Black and White Screen

% White in Black and White Screen	2	4	9	12½	18	25	29	33	37½	50
Total Flies Caught	101	99	98	101	99	114	91	93	85	61
No. of Black/White Screen	39	34	24	23	21	26	18	14	8	4
No. on Black Screen	62	65	74	78	78	88	73	79	77	57
% Flies Caught on Black Screen	67·4	65·7	75·5	77·2	78·8	77·2	80·28	4·9	90·6	93·4

The catch on the black screen formed a progressively greater proportion of the total catch as the amount of white in the black and white screen increased. The white was added, in each case, as three equally spaced horizontal stripes.

certain colours of screens over others. The present work concerns the importance of the visual sense in the attraction of *Haematopota insidiatrix* towards its host. Two facts prove that the *H. insidiatrix* attracted to the screens were coming to feed. First, all the flies caught were female; the males, which do not suck blood, were not attracted. Secondly, the flies landing on the screens probed the surface with their mouthparts.

Three black screens (24, 16, and 8 sq. ft. in area) were carried in procession. Each screen attracted more flies when carried first in the procession than when carried second and third. The models were rotated so that each occupied the three possible positions an equal number of times. The total number of *H. insidiatrix* caught on the first, second, and third screens was 100, 58, and 60 respectively. The number of flies attracted also varied according to the size of the screen. Ninety-nine flies were caught on the largest screen, 76 on the medium screen, and 43 on the smallest one. However, approximately the same number of flies were caught per sq. ft. of surface (4·12 on the large, 4·75 on the meduim, and 5·48 on the smallest screen). It was also found, by comparing two screens simultaneously, that a black screen is much more attractive than a white one of the same size (137 *H. insidiatrix* on the black screen, 5 on the white screen), and that the attractiveness of a black screen is diminished progressively as more white is added to it (Table 1.).

This decrease in the attractiveness of the screen might be due to the increasing amount of white or to the decreasing amount of black or to both; also, the change in the continuity of the black surface may prove to be involved.

This investigation is to be continued in the wet season of 1959 to 1960, and will be reported in full elsewhere.

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Robert Barrass*
University College of Rhodesia and Nyasaland,
Salisbury, Southern Rhodesia.
May 4.
* Wellcome Research Fellow in Zoology

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Ants and Form Reversal in Aphids

El-Ziady and Kennedy[1] found that in colonies of *Aphis fabae* Scop. which were attended by ants there was a higher rate of multiplication and delayed production of winged forms compared with unattended colonies. It has been suggested that the higher rate of multiplication is a result of ant-attendance delaying dispersal of the aphids from the nutritious apical growth of the host plants[2]; and it seemed probable that the delayed production of winged forms may have been due to the same cause. However, ant-attendance does cause a marked increase in the feeding rate of aphids[3] and the possibility of it having a more direct inhibitory effect on the development of winged forms was not ruled out. In the present communication such an effect is reported.

When the progeny of apterous parents of *Aphis craccivora* Koch undergo their development on mature leaves of broad bean (*Vicia faba* L.) which are detached from the plant and kept in tubes of water, a large proportion of them develop into alatae[4]. A series of experiments was carried out to determine whether ant-attendance of the developing nymphs had any influence on their continued development as alatae. Apterous parents were left on leaves until they had deposited the required number of nymphs. They were then removed and the leaves bearing the nymphs were put in a cage close to a nest of small black aphidicolous ants, *Paratrachina* (*Nylanderia*) *baveri* Mayr. The ants were denied access to half the leaves by keeping the jars in a shallow tray of water to which a little detergent had been added; they tended the aphids on the other leaves in the manner described by Banks[2].

The results of four separate experiments are given in Table 1. High percentages of nymphs which had been

Table 1. Percentages of Aphids Which Developed into Apterae in Batches of *A. craccivora* which were Ant-Attended and not Ant-Attended as Nymphs

Exp. No.	Period of attendance by ants	Ant-attended: Mean % apterae	Ant-attended: No. of leaves	Ant-attended: Total No. of nymphs	Not Ant-attended: Mean % apterae	Not Ant-attended: No. of leaves	Not Ant-attended: Total No. of nymphs
1	Whole of immature stages	98·5	5	395	27·5	5	425
2	1st instar only	88·0	5	208	37·0	5	193
3	2nd instar only	100	1	30	10	1	30
4	3rd and 4th instars	0	5	169	0	5	142

attended by ants for the whole of their development, for the first instar only, and for the second instar only, developed into normal apterae. A few of them had rudimentary ocelli, but none had wing pads or other alatiform structures. Most of the aphids in the control series developed into alatae. Thus it appears that ant-attendance during the early instars resulted in the nymphs being diverted from the alate course of development. Nymphs attended by ants during the third and fourth instars only were not affected and continued to develop into normal alatae.

As aphids imbibe more food when they are attended by ants than when they are unattended, and as apterae can also be produced by allowing first and second instar nymphs to feed on host seedlings[5], form reversal might be attributable to improved nutrition. But, in the experiments described, the ant-attended aphids did not grow any more rapidly, nor did they attain a larger size, than the controls. Thus nutrition was not a limiting factor in development. If form

reversal was effected through nutrition, it could have been a response to the accumulation of some specific substance. On the other hand, it is probably due ultimately to a change in endocrine activity[4], and this might well have been brought about independently of nutrition.

Aphids of many species are attended by ants, and the influence of ants in causing the suppression of alatiform structures in developing nymphs is undoubtedly of widespread occurrence. But alate aphids are sometimes produced in large numbers, particularly on wilting or dying host plants. On such plants, the aphids' rate of feeding, and thus excretion, are reduced. As a result, fewer ants tend the aphids: individual aphids are visited less often, and there must come a stage when the effects of infrequent ant-attendance are outweighed by the alate-favouring factors of the aphids' environment, and the aphids then develop into alatae.

BRUCE JOHNSON

Waite Agricultural Research Institute,
University of Adelaide.
May 12.

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MICROBIOLOGY

Transaminases in *Shigellæ*

NUMEROUS investigations have been made of the transaminase system in bacteria, and these have been reviewed by Meister[1]. The only reference to the transaminase activity in *Shigellæ* appears to be the one mentioned by Lichstein and Cohen[2] on a strain of *Shigella dysenteriae* (*Shiga*).

Using acetone-dried cell preparations, the transaminase activity of nine strains of *Shigellæ* was studied. The strains were chosen from the four serological groups, and were *Shigella dysenteriae* 6, *Shigella dysenteriae* 7, *Shigella boydii* 2, *Shigella boydii* 3, *Shigella boydii* 5, *Shigella flexneri* 1a, *Shigella flexneri* 2a, and two strains of *Shigella sonnei*. The strains were grown on nutrient broth[3] at 37° C. for 18 hr. and seeded on to the surface of 1·8 per cent nutrient agar (New Zealand agar) in Roux bottles. Following overnight aerobic incubation at 37° C., the growth was washed off with ice-cold sterile double-distilled water and an acetone-dried cell preparation obtained by the method of Umbreit *et al.*[4]

Four keto-acids, α-ketoglutarate, oxalo-acetic acid, sodium pyruvate and sodium phenyl pyruvate were used in concentrations of 0·25 *M* at *p*H 8·2. The amino-acids serving as NH_2-group donor were *l*-arginine, *dl*-methionine, *dl*-histidine, glycine, *dl*-serine, *dl*-tryptophan, *dl*-valine, *dl*-aspartic acid, *dl*-phenyl alanine, *dl*-alanine and *dl*-glutamic acid. *dl*-Tryptophan, *l*-arginine and glycine were prepared in concentrations of 0·1 *M*; all other amino-acids were in concentrations of 0·2 *M*. The experiments followed, in general, the methods described by Gunsalus and Stamer[5]. The reactants were 0·1 ml. *M*-phosphate buffer (*p*H 8·3), 0·2 ml. of a homogeneous aqueous suspension of acetone-dried cells (30 mgm./ml.), 0·2ml. pyridoxal phosphate (0·5 mgm./10 ml.), 0·2 ml. amino-acid, 0·1 ml. keto-acid and water to make up to 1·0 ml. The reaction of the mixture was adjusted to *p*H 8·2. The cell suspension boiled at 100° C. for 3 min. was used as control for each amino-acid – keto-acid experiment. The tubes were incubated for 60 min. at 37° C., and the reaction stopped by boiling at 100° C. for 5 min.[6] The tubes were centrifuged at 3,000 r.p.m. for 30 min., and approximately 0·002 ml. of the supernatant examined for the presence of the amino-acid corresponding to the keto-acid used, by qualitative paper chromatography.

With all the strains used, the following reversible reactions were shown to occur:

(*a*) glutamic acid + oxaloacetic acid ⇌ aspartic acid + ketoglutarate;

(*b*) glutamic acid + sodium pyruvate ⇌ alanine + ketoglutarate;

(*c*) glutamic acid + sodium phenyl pyruvate ⇌ phenyl alanine + ketoglutarate.

In addition, aspartic acid was formed in the reaction between phenyl alanine and oxaloacetic acid with cell preparations of the strains of *Shigella dysenteriae* 6, *Shigella boydii* 3, *Shigella boydii* 5, and one strain of *Shigella sonnei*. Alanine was present in the supernatant of the reaction mixture containing aspartic acid and sodium pyruvate with the strains of *Shigella dysenteriae* 3, *Shigella boydii* 3 and *Shigella boydii* 5. With the strains of *Shigella boydii* 5 and *Shigella dysenteriae* 6, alanine was also formed in the reaction between phenyl alanine and sodium pyruvate.

Of the four keto-acids, α-ketoglutarate was most active, and showed reactions with methionine, valine, tryptophan, phenyl alanine, alanine and aspartic acid. Phenyl pyruvate showed the lowest activity. Of the two remaining keto-acids, both of which were poorer amino acceptors than ketoglutarate, oxaloacetic acid was slightly more active than sodium pyruvate. Among the amino donors, glutamic acid showed reaction with the three keto acids, and the reaction could be demonstrated with all the strains used. Under conditions of the test, none of the strains was able to show transamination reactions with glycine, serine, histidine and arginine, and any one of the four keto-acids.

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RANJIT SEN

Department of Bacteriology,
University College, Ibadan,
Nigeria, West Africa.
May 11.

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Light-Induced Production of Carotenoid Pigments by *Cephalosporia*

THE pink and orange pigmentation in cultures of various members of the form genus *Cephalosporium* has been noted by several authors[1]. Roberts[2] presents a table including descriptions of the colony colour of a number of *Cephalosporium* species and strains without

mentioning the influence of light. So far as is known only four authors[3] mention briefly the influence of light on colour formation in this genus and without attaching any significance to their observations.

A survey of 75 *Cephalosporia* has revealed that this genus can be divided into three groups depending on their colour production in response to light.

Group I: Those which produce no pink or orange pigments when grown in light or darkness (25 strains).

Group II: Those which produce pink or orange pigments when grown in light, but which produce no such pigments when grown in darkness (48 strains).

Group III: Those which produce pink or orange pigments in light and also produce smaller quantities of these pigments when grown in darkness (2 strains).

This survey indicates that descriptions of colony colour in *Cephalosporia* are valueless unless the lighting conditions under which cultures are grown are defined. The production of pigments by *Cephalosporium* cultures in response to light provides a further useful character for sub-classifying the genus.

The pigment production of one species in Group II, *C. diospyri* Crandall, has been examined more closely. It has been shown that both continuous artificial light and normal daylight induce a similar intensity of pigmentation. Cultures grown in total darkness and showing no visible pink or orange pigmentation rapidly produce pigment when exposed to light and become as fully pigmented as continuously illuminated cultures. A similar phenomenon has been noted with *Phycomyces blakesleeanus*[4] and *Dacrymyces ellisii*[5]. From visual comparison of the pigmentation of colonies of *C. diospyri* on a number of complex organic media and on two synthetic media, it is clear that pigmentation is most intense on media with a high carbon/nitrogen ratio and/or with a high concentration of carbohydrate. The pigment production of illuminated cultures of *C. diospyri* is totally suppressed by diphenylamine at concentrations below that required for inhibition of growth. This fact suggests[6] that the coloured compounds produced are carotenoids and this is supported by (*a*) the dark-blue colour given by the extracted pigments with concentrated sulphuric acid, (*b*) the behaviour of the pigments on chromatographic columns, and (*c*) the characteristic light-absorption spectra of the fractions. So far as is known, this is the first recorded instance of the extraction and isolation of carotenoids from *Cephalosporia*. Although Pinkerton[3] made the suggestion that the colour of *C. kiliense* might be related to xanthophyll, no pigment was successfully extracted.

Pigment for chemical characterization was produced in illuminated surface cultures on malt extract medium. The fully pigmented felts were harvested, washed and mechanically reduced to a fine pulp. The pigments were extracted from this pulp by a procedure based on that used by Haxo[7] for the extraction of the carotenoid pigments of *Neurospora crassa*. The light petroleum epiphase obtained after saponification was chromatographed on graded alumina columns; in this way one major and four minor carotenoid fractions were separated.

Table 1

Solvent	Absorption spectrum maxima (mμ)				
Carbon disulphide		~405–410	495	525*	561
Benzene		390	472	503*	537
Chloroform		390	467–471	494–496*	518–520
Ethanol		~361–364	380	462	488* 520
Light petroleum (40–60°) †	306–308	~360–362	378	456–458	482* 514 516

* Peaks with highest absorption maxima.
† Absorption maxima in light petroleum were determined using a different sample of the carotenoid.

Table 1 contains the light absorption data for the major carotenoid.

This main red carotenoid contains no free –COOH group, and since it is entirely epiphasic when distributed between light petroleum and either 90 or 95 per cent methanol, it presumably contains no free –OH group.

Unequivocal identification of this red carotenoid has not yet been completed. There are at least three known carotenoids (*P*481[8], spheroidenone (pigment *R*)[9] and torulin[10] whose published light-absorption data do not differ significantly from those given in Table 1. Further work on this point is now in progress with the view of establishing the identity of the main red carotenoid produced by *C. diospyri*.

One of the minor fractions has been identified as lycopene.

R. C. Codner
B. C. Polatt

Antibiotics Research Station,
Medical Research Council,
4 Elton Road,
Clevedon,
Somerset.
April 7.

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Effect of Iron and Zinc on Nucleic Acid and Protein Synthesis in *Mycobacterium smegmatis*

We have observed[1] that some cultures of *Mycobacterium smegmatis* on modified Proskauer and Beck medium[2] stopped growing, and the pellicle sank before the usual yield of cells had been obtained. After growth had stopped, the bacilli in these cultures were very elongated and contained a low level of deoxyribonucleic acid (expressed on a protein nitrogen basis), compared with normal cultures of the same age.[1]

We have now found that the above condition results from a deficiency of either iron or zinc in the medium. Unless both of these metals are present in suitable amounts (2 μgm./ml. iron; 0.4 μgm./ml. zinc), growth is inhibited before the other constituents of the medium are fully utilized. Deficiencies of these metals inhibit the growth of other mycobacteria too, as other workers also have found[3–7]. Other trace metals added singly had doubtful effects in improving the yield further, though a 'cocktail' of calcium, manganese, boron, copper, cobalt and molybdenum in suitable amounts did give a slight improvement.

Table 1. Effect of Iron and Zinc on the Yield and on the Levels of Phosphorus Compounds in *Mycobacterium smegmatis* Grown on Proskauer and Beck Medium Partially Freed of Trace Metals by Autoclaving with Alumina.[8] Phosphorus Compounds were Estimated by the Methods of Winder and Denneny[1]

Age of culture	Yield per 45 ml.	U.V.-absorption at 260 mμ	Acid-labile	Acid-stable	RNA	DNA	Inorganic polyphosphate	Lipid phosphorus
	Acid-soluble Fraction				Acid-insoluble Fraction			
(days)	(mgm. Protein N)	*E* (1cm., 1μgm. protein N/ml.	(mgm. P/gm. protein N)					
2+2 μgm./ml. Fe+0·4μgm./ml. Zn. added								
2·3	*c.* 1·2	28·0	8·4	24·3	105	38	21	9·8
3	12	16·1	8·4	26·4	82	33	32	8·5
4	22	16·0	6·3	20·0	56	66	61	8·3
5	27	16·2	4·9	15·3	48	83	83	8·2
No addition								
2·3	*c.* 1·3	26·4	8·6	26·4	93	38	50	9·6
3	1·8	26·0	7·1	23·0	63	30	133	12·3
4	2·1	25·3	5·9	18·6	54	28	140	12·0
5	2·7	25·0	4·7	14·3	51	26	149	11·6

For the first two days, cultures deficient in iron and zinc were almost identical with similar cultures to which these metals had been added (Table 1). The cultures provided with metals grew rapidly for about a further day and then slowed down to a stationary state. The concentration of ribonucleic acid dropped as the rate of growth diminished, and a slow increase in 'insoluble' inorganic polyphosphate concentration occurred. A sudden increase in deoxyribonucleic acid concentration occurred at about four days, when increase in protein had practically stopped. Microscopic examination showed that at the same time the predominantly elongated, apparently multi-cellular rods of the younger cultures were replaced by short, unicellular rods.

The traces of iron and zinc in the deficient medium were exhausted after two days and an abrupt decrease in the growth rate, as measured by protein nitrogen, occurred (Table 1). This was preceded by a drop in the concentration of ribonucleic acid, and accompanied by a cessation of synthesis of this acid. The subsequent slow increase in protein and ribonucleic acid was probably due to leaching of metals from the glass. The decreased rate of growth was accompanied by a drop in concentration of deoxyribonucleic acid, instead of the sharp increase which normally accompanied cessation of growth. These results suggest that the primary effect of a deficiency of iron or zinc is on synthesis of ribonucleic acid. The cessation of synthesis of this acid may cause the inhibition of synthesis of protein and deoxyribonucleic acid. A striking increase in 'insoluble' polyphosphate concentration, which started even before measurable growth inhibition was observed, showed that the decrease in growth-rate involved inhibition of the utilization of, but not of the formation of, high-energy phosphorus compounds. In these cultures the bacilli remained elongated, and many were even filament-like.

In normal cultures the acid-soluble, ultra-violet-absorbing substances dropped abruptly in concentration when growth started to slow down; but the level of these substances in the metal-deficient cultures did not fall. This suggests that cessation of growth is normally caused by cessation of synthesis of some of these ultra-violet-absorbing substances, but that in the case of iron or zinc deficiency their utilization is diminished. These compounds include nucleotides and flavins, and we hope that their fractionation and further study will provide information on how iron and zinc control ribonucleic acid, deoxyribonucleic acid and protein synthesis.

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Frank Winder
Joan M. Denneny
Laboratories of the M.R.C. of Ireland,
Trinity College, Dublin.

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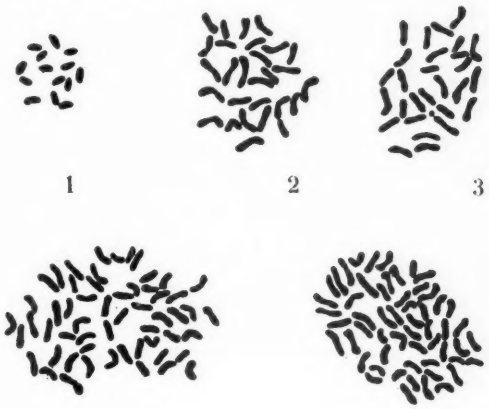
CYTOLOGY

Cytology of the Genus *Sanguisorba*

The genus *Sanguisorba* L., comprising about 40 species, has been the object of several cytological and taxonomical studies during recent years. Thus we have already gained a rather good idea of the cytological pattern of this genus[1,2]. In particular, specimens of the form complex *Sanguisorba minor*, from all over its distribution area, have been studied. The species forms a polyploid series of 7. Up until now tetraploids, hexaploids and octoploids have been found, but never diploids. I have examined neighbouring monotypic genera with woody structure[3,4]; they too turned out to be tetraploids, namely, *Bencomia caudata*, *Dendriopoterium menendezii*, *Marcetella moquiniana*, and *Poterium spinosum*.

Recently five species grown in the Botanical Gardens of the University of Copenhagen were fixed for chromosome countings. The chromosome numbers, none of which has been reported previously, were found to be the following.

S. annua Nutt. .. .. $2n = 14$ (Fig. 1)
S. alpina Bunge .. .. $2n = 28$ (Fig. 2)
S. obtusa Maxim. var. *amoena* Jess. .. .. $2n = 28$ (Fig. 3)
S. canadense L. .. .. $2n = 56$ (Fig. 5)
S. tenuifolia Fisch. ex Link .. .. $2n = 56$ (Fig. 4)



Figs. 1–5. Root tip mitoses from: 1, *Sanguisorba annua*; 2, *S. alpina*; 3, *S. obtusa* var. *amoena*; 4, *S. tenuifolia*; 5, *S. canadense*. The scale is 10 μ

S. annua Nutt. is an annual species widely distributed in North America. It is reported to act occasionally as a biennial. It has been referred to a separate genus *Poteridium* Spach. It is the first diploid species found in the tribe Sanguisorbeæ. As seen from Fig. 1 the chromosomes are smaller than in the other species of *Sanguisorba*. This might indicate that *S. annua* is a more distant relative of the other *Sanguisorba* species.

S. alpina Bunge is a perennial species widely distributed in sub-alpine meadows in eastern Siberia and the Mongolian Republic. It has chromosomes of the typical *Sanguisorba* type.

S. obtusa Maxim. var. *amoena* Jess. is a perennial native of Japan where it is found at high altitudes. It is very closely related to *S. hakusanensis* Makino which might perhaps be regarded as a variety of *S. obtusa*. In *S. hakusanensis*, $2n = 28$ was found by Sakai[5], that is, the same number as that found by me in *S. obtusa*.

S. canadense L. is a North American perennial found in swamps from Labrador and Newfoundland to Georgia and Michigan, and as var. *japonensis* it is also found in Japan. $2n = 56$ was found in the typical form whereas the Japanese variety has not been examined.

S. tenuifolia Fisch. ex Link is a hybrid between *S. officinalis* L. and *S. parviflora* (Maxim.) Takeda. It has the same distribution as *S. parviflora* and is frequently found among the parents often more predominantly than the pure species, or to quote Hulten[6]: "Sporadically all specimens of the genus *Sanguisorba* in Kamtchatka—if we exclude the rare pure *S. officinalis*—form a continuous series between the two species". The chromosome number was found to be $2n = 56$. The same number was found in *S. officinalis* from Hungary, U.S.S.R., and Sweden. The present findings indicate that *S. parviflora* also may be considered to be an octoploid species with $2n = 56$.

Kai Larsen

Royal Danish School of Pharmacy,
Botanical Laboratory,
Copenhagen.

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SOIL SCIENCE

Occurrence of Microbiological Filaments in Soils

While sieving sands from south-eastern South Australia to determine the particle size distribution, considerable difficulty was experienced in obtaining clean separations. For example it was found that after shaking for 10 min. on a mechanical sieving machine 2·2 gm. of sand passed the 200-mesh (0·08 mm.) screen, whereas an additional 10 min. sieving yielded a further 2·4 gm. Thus in this case the true amount of the sand below 0·08 mm. equivalent diameter was increased from 10 per cent to a value of 20 per cent of the original sample.

The 8-in. diameter sieve was in good condition; a careful inspection failed to reveal any damaged or irregular apertures. The sand remaining on the sieve was examined under a binocular, stereoscopic microscope; there was no abnormality in size or shape of the quartz grains. However, it was seen that many of the sand grains were held together by fine filaments which adhered to the individual mineral particles. Some of the finer sand grains were completely enmeshed in a mass of these filaments, while many larger grains were bound to the larger diameter filaments when they divided to form a flat mat adhering to one side of the grain (Fig. 1). The soils had been dispersed in the presence of sodium hydroxide and sodium polyphosphate in the standard mechanical dispersion apparatus. The sands were afterwards separated by repeated stirrings and decantation after the appropriate time. The filaments must be quite strong to withstand this treatment. This was confirmed by the difficulty experienced in separating the sand grains mechanically while observing them under the microscope. It would thus appear that the eventual breaking of these filaments during the extended period of sieving freed the finer material enabling it to pass through the screen. Confirmation of this was obtained by screening a sample after prior ignition. Under these conditions practically the whole of the fine material was obtained in the initial period of 10-min. sieving.

The filaments appeared to be organic material as they were easily destroyed by ignition. They were somewhat basiphilic, as they stained with aniline blue, and were probably of microbiological origin. Many filaments exhibited a branching form, sometimes with change in diameter. Others which were of larger diameter and more uniform showed well-developed cross walls and less branching. Most filaments were hyaline, some were coloured, usually brown, rarely green or blue.

Afterwards many soils from the collection of the Division of Soils, C.S.I.R.O., were examined and it was found that the small aggregates (less than 2mm.) from most surface horizons contained similar but usually finer filaments. These filaments formed a strong network within the soil crumbs. Soils examined included samples from Adelaide, Barossa Valley, Mt. Compass and County Robe in South Australia and Lismore in New South Wales.

Fig. 1. Photomicrograph showing organic filaments in Mount Compass Sand. The aggregate on the left is strongly bound together by very fine filaments; other coarser filaments ramify from it as well as appearing elsewhere in the field. (×4).

These filaments could have a marked strengthening effect on the stability of soil crumbs. Their influence on the structure of soils and the binding of sands is being further examined; the nature of the micro-organisms concerned is also being investigated. The persistence of their binding action on sand particles even after considerable mechanical treatment during dispersion of soils stresses the need to ignite all sands prior to detailed sieving for their fractionation.

I am grateful to Mr. J. R. Harris for the benefit of discussions with him on the microbiological aspects of these filaments and for taking the photomicrograph used for Fig. 1.

ROY D. BOND
Commonwealth Scientific and Industrial Research Organization, (Division of Soils), Adelaide.
June 17.

Titration Curves of Soil Organic Matter

IN a previous paper[1] it was claimed that the addition of small amounts of copper sulphate to a suspension of acid-washed organic matter resulted in the release of two hydrogen ions for each of added copper. This release was detected by titration of portions of the organic matter with alkali in the presence and absence of copper (ref. 1, Fig. 5). Further experiments with organic matter extracts of peats and podzols have not confirmed a general proton release of this magnitude and are in conformity with the results of Martin and Reeve[2]. These authors revealed new complications in such experiments, in particular the important association of aluminium with soil organic matter and the difficulty of removing this metal. The purpose of this note is to correct the inaccuracy in my earlier paper and to add further information on the ability of soil organic matter to complex transition metals.

Chelation reactions can occur with, for example, copper without the demonstrable release of two hydrogen ions per metal atom[3]. This fact was not recognized during some previous discussions of chelates in soils[1,2], but can be illustrated by titrations of several carboxylic acids. When oxalic acid is titrated with alkali, the addition of even the equivalent amount of copper does not displace the end-point of the titration curve. On the acid side of the end-point the extra alkali consumed, in the presence of copper, is less than the stoicheiometric amount and differs at different *p*H values.

Some hydroxy carboxylic acids and salicylic acid show another relationship. The hydrogen of the OH groups becomes titratable with alkali in the presence of metals, such as copper, which form stable chelate compounds. The titre of these acids increases by an amount proportional to the copper added for additions less than the equivalent of the acid present. The extra alkali consumed at the end-point is equivalent to one hydrogen ion per atom of added copper. If excess copper is added, part is precipitated as a basic salt at its usual *p*H of 'hydroxide' precipitation, and this part requires the normal amount of alkali, namely, approximately 1·6 hydroxyl ions per atom of copper. These relationships are exemplified by citric acid with three levels of added copper (Fig. 1). The second level of copper approximates to the maximum amount which can be chelated by the acid present. The highest addition is twice the second, and the additional displacement of the end-point is about 1·6 times that produced by the second level of copper. The general reaction of α-hydroxy acids with copper can be written:

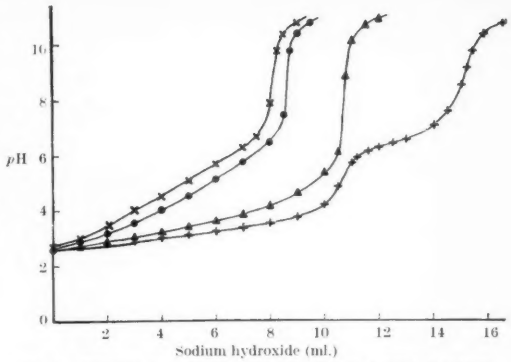
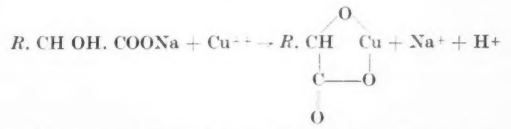


Fig. 1. Titration of 10 ml. 0·02 *M* citric acid with 0·075 *N* sodium hydroxide: ×, citric acid alone; ●, +2 ml. 0·02 *M* copper sulphate; ▲, +10 ml. 0·02 *M* copper sulphate; +, +20 ml. 0·02 *M* copper sulphate



Martin and Reeve[2] have shown the effect of the partial removal of aluminium on the titration curve of podzol organic matter. Their results have confirmed the evidence of Aleksendrova[4] that iron and aluminium block carboxyl groups on the organic matter. The question remains as to whether other organic groups are simultaneously involved, the metals thereby being chelated.

One difficulty in interpreting titration curves of organic matter in terms of models has been the determination of the end-points of the curves. By techniques to be reported elsewhere, Reeve and I have succeeded in preparing organic matter extracts containing only traces of mineral constituents. Titrations of these preparations have given much less ambiguous end-points and, when suitable amounts of copper are added, give curves showing the same relationships as those of chelating hydroxy acids. Fig. 2 shows results

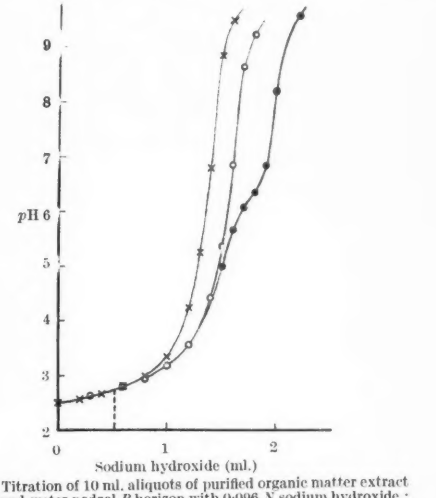


Fig. 2. Titration of 10 ml. aliquots of purified organic matter extract from ground-water podzol *B* horizon with 0·096 *N* sodium hydroxide: ×, organic matter alone; ○, +1 ml. 0·02 *M* copper sulphate; ●, +2 ml. 0·02 *M* copper sulphate

obtained with a purified organic matter extracted from the *B* horizon of a Tasmanian ground-water podzol. Part of the acidity of this preparation (indicated by the dotted line) was due to free hydrochloric acid. Other experiments have shown that the presence of neutral salt in such systems does not alter the displacement of the end-point in the presence of copper.

Although Martin and Reeve[2] doubted whether chelates were found in any of their organic matter systems, the curves which they obtained with purified podzol humus (ref. 2, Fig. 6) appear to be compatible with the present interpretation. Their other evidence resulted from application of the test of Gregor *et al.*[5]; this test has proved unreliable in application to citric acid systems.

Accumulated evidence leading to the conclusion that transition metals can be chelated by soil organic matter need not be summarized here. However the present evidence appears to provide the first indication of the identity of the binding sites, namely carboxyl and phenolic or hydroxylic groups. Amino- or imino-acids could give titration curves showing the relationship described for hydroxy acids but the amount of copper chelated in these experiments exceeds that which could be bound even by the whole of the nitrogen present. Published figures on the OH content of organic matter are, on the other hand, compatible with the amount of copper bound.

I gratefully acknowledge the benefit of discussions of this problem with both A. E. Martin and R. Reeve. However, the conclusions reached are not necessarily accepted by these workers. I am also indebted to Prof. G. W. Leeper for valuable suggestions during the preparation of this manuscript.

R. S. Beckwith

Commonwealth Scientific and Industrial
Research Organization,
Division of Soils,
Cunningham Laboratory,
Brisbane.

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Nitrogen Fixation in a Uganda Swamp Soil

Information about the swamp-soils of Uganda is important since their agricultural potentialities are largely unknown and the swamps cover a large part of the surface of the country. Work on the relationship between the nitrogen status of some tropical soils and the water regime applied to them has given particularly interesting results with a sandy soil from a papyrus swamp at Namulonge, near Kampala.

400-gm. samples of soil were placed in 18 shallow jars of thick glass giving a soil layer about 5 cm. deep. Distilled water was added to each preparation to give three groups with (1) soil at saturation capacity, (2) soil completely water-logged to the surface and (3) soil flooded under a layer of water 2 cm. deep. Each group was divided into two sets (triplicates) where (*a*) moisture status was maintained by restoration of water loss after daily weighing and (*b*) water was allowed to evaporate until the soil became completely air-dry as shown by constancy of weight of the preparation. The latter samples then received distilled water in the original quantity so that a drying and wetting cycle occurred. The experiment ran for nine weeks, the jars being placed on an open flat roof under a stretched polythene sheet excluding dust and insects but not obstructing ventilation. Temperature in the preparations varied between 19° C. (8 a.m.) and 36° C. (in full sunlight).

Kjeldahl nitrogen determinations were carried out separately (i) on supernatant liquid when it was present and (ii) on the soil plus organisms homogenized by hand grinding. Combined results are given in Table 1. Nitrate-nitrogen determinations by the phenoldisulphonic acid method failed because of the presence of organic matter. Ammonium-nitrogen was also determined but did not exceed 3 per cent of the Kjeldahl value.

Table 1. Triplicate Groups of Kjeldahl-Nitrogen Values for Namulonge Swamp Soil in P.P.M. on an Oven-Dry Basis (105° C.)

		Water status maintained			Alternately wetted and dried*		
	Outset	Saturated	Water-logged	Flooded	Saturated	Water-logged	Flooded
	600	435	585	585	585 (4)	870 (5)	1190 (3)
	710	575	730	540	560 (5)	585 (5)	1090 (4)
	560	440	595	565	565 (4)	540 (4)	905 (3)
Mean	623	483	637	563	570	665	1062

* Figures in parentheses show the number of wet/dry cycles undergone by the preparation.

Considerable increase in nitrogen occurred only where preparations were alternately flooded under 2 cm. of water and allowed to dry out. The effect is probably related to that observed by Birch and Friend[1] in which the rate of soil respiration corresponds to cyclic wetting and drying but the influence of the layer of water remains to be explained. The control of the depth and duration of such a layer clearly may be of much importance in crop-production on soils of this type.

In every preparation a luxuriant growth of blue-green algae occurred either as a gelatinous sheet on the surface of the soil or as lobed floating masses in the water layer. *Anabaena* spp. were identified as part of the complex in every case and the nitrogen-fixing properties of *Anabaena* are well known, but the problem remains why they were ineffective in the majority of the preparations.

Preliminary experiments have shown that minute inocula from the jars initiates good growth of blue-green algae (*Anabaena* predominating) in a nitrogen-free liquid medium[3]. The growth is continued if such cultures are allowed to dry out and particles of the residue transferred to fresh medium.

The situation in this type of swamp soil seems to be similar to that described for the rice-growing soils of parts of India[2] and the use of some Uganda swamps for agricultural purposes may involve methods similar to the Indian.

E. A. Calder

Department of Botany,
Makerere College,
University College of East Africa,
P.O. Box 262, Kampala,
Uganda.
May 11.

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